

## General comments

The term “state space” is vague in my opinion. The introduction could refer to the paper that coined the term ‘state space’ or discuss why this is an appropriate name.

This paper seems to shy away from any results that are in contrast with its companion paper. Firstly, the turnaround near 40°S appears to occur in late 2001, which is not ‘around 1997’. Secondly, the opportunity to point out that the piecewise trend model does not seem appropriate for a large number of altitude/latitude combinations was not seized. The price of using a piecewise linear trend model is that for locations where the trend is decreasing for the entire 1984-2011 time frame, one can end up with two trends that are statistically insignificant, whereas a single statistically significant trend (1984-2011) could have been obtained had one not used a piecewise approach. The paper hints at this, but such a statement would show the value of using a DLM.

There is only one plot (showing the trend) using results on the 1 km vertical grid. It would make sense to include a plot of the seasonal effect at low latitude and high altitude (e.g. 0-10°S, 45-55 km) to illustrate that the model can capture changes in seasonality with altitude and latitude. The authors should make the case that this method should replace static multiple linear regression (MLR) methods by comparing their fitting residuals to those from a static MLR. This would be simple for the authors to do. As they point out, it consists of setting model error variances to zero. It would be useful to see an example of whether the dynamic model helps to capture the interannual variability of the seasonal effect (or abrupt changes in ozone following a volcanic eruption as they claim in the introduction).

Showing the fit quality at 20 km (1 km) in an equatorial band (0-10°S) would be revealing as the solar term should be insignificant whereas omitted predictors such as El Nino Southern Oscillation (e.g. ENSO) will be significant. Figure 5 shows a significant positive trend change at the equator at 20 km whereas the abstract says the dataset covers the 25-55 km range with 1 km spacing. I doubt whether the statistically significant +10%/decade trend change at 20 km at the equator is correct because of an overly simplified and inappropriate model. The authors have analyzed a large range of altitudes and latitudes with an admittedly “conceptually simple” approach and I am concerned about the accuracy of the resulting trends, particularly in the tropical lower stratosphere, where there is plenty of variability unexplained by this model. The paper seems to be more of a ‘proof of concept’ with ad hoc choices of 0.06% of the mean level of the observations and a standard deviation of 80% (log-normal distribution). It would improve the paper if the impact on trends (Figure 5) was determined for:

- 1) a change in the standard deviation of the yearly level change from 80% to e.g. 40%
- 2) a change in the distribution from log-normal to normal
- 3) a change in the yearly level change mean from 0.06% to 0.0833% (1/12 of 1%)

or the authors could provide some justification for their selected settings.

The inclusion of a solar term without the inclusion of more important proxies at 20 km could possibly lead to incorrect trends, partly because of the long period of a solar cycle. The authors are essentially deriving two trends that are of approximately the same

period as one solar cycle. I suggest the authors add one additional, appropriate proxy variables (e.g. ENSO) and examine the trend changes near 20 km at the equator. It is also not clear whether, in generating Figure 5, that the authors determine a single solar regression coefficient for the 1984-2011 time period or if two solar regression coefficients are obtained (one for 1984-1997 and one for 1997-2011). It definitely seems like the former, and this is the more reasonable option, but the authors should clearly state that they did not redo the statistical modelling for two shorter time periods, and that they are simply calculating two trends based on their modelling of the entire time period (1984-2011). The trend change differs by 5% (from +5% to +10%) between the companion paper and this one, respectively, near 20 km at ~10°N. Note that the companion paper also excludes ENSO while including a solar term.

### **Specific science comments and questions**

Define  $q$  in section 2.2

I object to the ‘“V” shaped’ description because, if I understand correctly, the companion paper could find a positive or negative trend for each of the two time periods.

What is meant by “estimating” a model? (Section 2.5)

P20517L20 What is meant by “drawing simulations”? Could this be replaced with “drawing realizations”?

Are the residuals in this work generally Gaussian with unit variance?

P20519L8 The statement “lesser quality of satellite observations” should be supported quantitatively or with a reference, or removed.

There is no discussion regarding the bottom three panels of Figure 2. The sign of the correlation between ozone and the predictor variables could be mentioned. The QBO terms appear to be added.

P20519L29 “before the year 2000”: not true for 35-45 km near 40°S

“..., the turning point is around years 1997-1998.” If one looks at Figure 4, the latitude height combinations with a clear ‘V’ are:

#### 45-55 km

30-40°N : 1999  
40-50°N : 1999  
40-50°S : 2000

#### 35-45 km

40-50°N : 1999  
20-30°S : 2000

30-40°S : 2001  
40-50°S : 2001 ... so I suggest that this is revised to 1999-2001 to be unbiased.

Conclusion: 1997 -> 1998

The word 'slight' is used but it makes sense to replace this qualitative statement with a quantitative statement like "~3 years".

It seems as though the authors are calculating RMSE relative to the mean 'level' number density and so I would expect RMSE values of <1. Include the units on RMSE (if any?) or present a formula to calculate RMSE.

Figure 2: For the second panel, it may be worth mentioning that the trend has not been removed.

Figure 3: When "densities" is used, does this mean "probability density"? If so, this should be clarified, since the reader could misinterpret density to mean ozone number density.

### **Editorial comments**

Title – "...state space..." -> "...the state space..."

P20504L12 "...well defined..." -> "a well-defined"

Is  $p(y_t|\theta_t)$  the same as  $p(\theta_t|y_t)$ ? The authors refer to the latter as a density, an observation, an uncertainty, a posterior uncertainty and a state. It cannot represent all of these.

Figure 1: "In lower left panel," -> "In the lower left panel,"  
"Lower right panel shown" -> "Lower right panel shows the"

Figure 4 - The trend shown in Fig. 4 at 50°S between 35 and 45 km seems inconsistent with the trend in Figure 5. In the former, the trend appears to be negative throughout the merged dataset, whereas the latter shows a positive trend at 50°S. I suggest that the y-axis labels in Figure 4 are switched to the midpoint of each latitude band (e.g. 45°).

P20504L21 "the atmospheric chemical compositions." -> "atmospheric chemical composition."

P20505L26 "...studies.In this article," -> "...studies. In this article,"

P20506L1 "volcanic eruptions." -> "volcanic eruptions, respectively."

P20506L2 "non uniform" -> non-uniform

P20506L12 ARIMA acronym remains undefined except in author's response.

P20506L22 “this arcticle” -> “this article”

P20507L3 “combination” -> “a combination”

P20508L5 “thru” -> “through” or “via”

P20508L5 build -> built

P20509L11-12 “So far the state ... have been time invariant” -> “So far, the variation with time of the state ... has not been detailed.”

P20509L17 “the Quasi-Biennial Oscillations” -> “Quasi-Biennial Oscillation”

P20509L21 “time varying” -> “time-varying”

P20510L5 “estimation the model states” -> “estimation of the model states”

P20510L10 “time independent” -> “to be time-independent”

P20510L10 “At first sight” -> “At first sight,” and for any other leading prepositional phrase

P20510L11 “under determined” -> underdetermined

P20510L14 “in conditionally” -> “is conditionally”

P20510L21 “times that t” -> “times than t”

P20511L2 “harder” -> “more intensive”

P20511L11 “found in the references (Petris...)” -> “found in Petris ...” or “found in the references (e.g. Petris...)”

P20512L22-24 “The interpretation for the terms as the size of the variability in the change of states between two time points provides a way to set prior constraints for these value”. This sentence makes very little sense as is. First “value” -> “values”. Here is my rewording:

Each **W** term represents the variability in a state parameter and serves to constrain the value for this state parameter at the next point in time.

P20513L3 “these parameter” -> “these parameters”

P20513L7 “shortly below.” -> “in section 2.4.”

P20514L19 “is studies” -> “is studied”

P20515L11 “asses” -> “assess”

P20515L12 “example, study” -> “example, we study”

P20515L15 “and for each sample calculate” -> “and, for each sample, calculate”

P20516L1 “step 2. to” -> “step 2 to”

Section 3 – The first five paragraphs of this section are mostly method-related and belong in Section 2.

P20517L3 “use locally linear” -> “use a locally linear”

P20517L17 “a Markov chain Monte Carlo (MCMC)” -> “an MCMC”

P20517L21 “Here” -> “Here,”

P20518L16 “Separate panel on lower left displays the 10 yr trend...” -> “A separate panel on the lower left displays the decadal trend...”

P20518L24 “second up-most” -> “second”

P20518L25 “possible realization” -> “possible realizations”

P20519L3 “results of ten year” -> “results of decadal” or “results of ten-year”

P20519L15 “The results of linear” -> “The results of the linear”

P20519L17 “We performed same” -> “We performed the same”

P20520L4 “long time” -> “long term”

P20520L19 “companying” -> “companion”

P20520L25 “changes are estimated opposite to the expected.” -> “estimated changes are opposite to those expected.”