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Climate of the Past Discussions



# *Interactive comment on* "Potential causes of 15th century Arctic warming using coupled model simulations with data assimilation" *by* E. Crespin et al.

**Anonymous Referee #3**

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This is a nice paper describing an innovative data assimilation scheme and a specific time period that has not received much attention. However, the text is relatively short and mostly qualitative. There could be more fleshing out of the interpretations (what would maintain a circulation anomaly?) and addressing some concerns with the model dynamics and the sparse coverage of proxy data.

Main concerns:

• The model is missing some key dynamics with respect to the climate system response to external forcing, so it is difficult to simply attribute data-model mismatches to internal unforced variability alone. • There are not enough proxy data from

the high Arctic to sufficiently constrain the model. The largest air temperature anomalies appear near the pole but there are no data there to confirm this pattern. • With respect to internal vs forced variability, the differences between the runs with and without data assimilation in the late 15th century do not appear to be unusual. Why not first focus interpretations on a period that has a larger offset? • How could the anomalies in air circulation be maintained for a period of 50 yrs or more and how different are the patterns in Figs 5 and 6 from the patterns in the forcing only ensemble for the same time period?

Further comments:

What would maintain the enhanced sw wind anomalies over the 50yr period?

Verify your claim of 2C warming from 1910s to 1940; Fig 4 itself does not show that much warming

How is volcanism induced through irradiance changes? Changes in the solar irradiance (solar forcing) and volcanism can have rather different dynamical impacts at the timescale that you’re considering (e.g. Shindell et al., 2003). A key difference is that while volcanic aerosol warms the stratosphere and cools the troposphere, an increase in solar irradiance warms the whole atmosphere, tending to strengthen the long-term dynamical response and the associated regional temperature anomalies at the surface. Thus, because of simplifications in the model and prescribed forcings, your simulations are probably missing some key dynamics, so it is not necessarily the case that differences between the forcing-only ensemble mean and the ensemble mean with data assimilation are due to unforced internal variability alone.

Although you say there does not seem to be a special forcing anomaly in the 15th century, there does actually appear to be a relative minimum in the solar proxy (Fig 1). At the least, please assess your assertion a little more explicitly & in detail. Even though there is an offset between the runs with and without data assimilation, the two ensembles track each other pretty well on the multidecadal to centennial scale.



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The sea ice is pretty important for Arctic climate – what does sea ice do in your simulations? The millennial trend in the forcing-only run perhaps suggests a growth of sea ice area with time…and/or slow changes in orbital forcing?

How is the seasonal representation of the proxies taken into account when you only consider annual means and decadal smoothing?

How is the number of ensemble members, 96, chosen?

Which instrumental surface temperature data are used?

If the proxies are decadally smoothed, standardized and scaled, how/why is the cost function evaluated for one-year- and 5-yr avgs? Decadal smoothing leads to substantial auto-correlation, so I don’t understand how is interannual variability preserved even if you do 1-yr computations of the cost function?

Some mistakes in grammer:

change “as show in Figure 3” to ‘as shown in figure 3”

change “…where proxies are available are showed” to “’where proxies are available are shown…”

change “as well good”

Figures 1 & 2: increase size of the axes and colorbar labels

Figure 1: The text says the model includes orbital forcing. Can you plot some representation of this on Figure 1, perhaps in terms on insolation anomalies at 60N?

Figure 2: the greens on the colorscale are too similar; it’s hard to tell what is positive and what is negative

Figure 3: the lines are difficult to read. They need to be darker/more distinct.

Figures 5 and 6: How do these patterns compare with the emsemble mean w/o data assimilation?



**CPD**

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How big of an offset is there really between the runs with data assimilation and without in the 15th century? It seems strange to focus on the late 15th century because there are other periods with much larger offsets, such as 1000-1400 and 1800-1840ish. Showing a difference plot to highlight this would be very helpful.

Plot proxies from Fig 2a on top of Figure 5 to show the comparison; with the difference colorscales it is hard to compare the two plots.

Fig 5: The max warming is in the central Arctic basin which has no data. This increasing warmth with higher latitude does not seem to appear in the proxies.

It seems that the early 20th warm period was much larger in amplitude than the 15th century Arctic warming, so it’s not clear that they result from the same mechanisms and SLP anomalies

How does the AL influence the Candaian Archipelago?

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