

Pintori et al. 2021

The manuscript “Common mode signals and vertical velocities in the great Alpine area from GNSS data” by Pintori et al. 2021 utilizes variational Bayesian Independent Component Analysis to separate loading signals due to atmospheric and hydrologic sources from vertical GNSS time series to further isolate uplift rates due to mountain building in the greater alpine region. This also serves to provide additional information on the source of the common mode signals in GNSS time series. In this study, they also compare the vbICA method to other methods of constructing the common mode. Finally, they remove the non-mountain building signals from the data and estimate uplift rates. Overall, the article is well written and is a useful contribution. However, there are a few areas that would benefit from additional clarification and added detail.

General comments:

ICA method in general

To my understanding, an ICA is meant to separate the different sources out of a given signal. This leads me to interpret that each component would thus represent a different source. However, throughout the paper it seems to me that each component is not necessarily a singular source (eg Figure 2). This component is obviously due to some combination of tectonic trend as well as some seasonal signal likely due to hydrology or atmospheric loading. If the point of using an ICA is to separate out different sources so that you can further isolate a specific source, how can you be sure that you are fully capturing the signal you think you are (in this case the tectonic signal or later on NTAL/HYDL)?

To this end, why are you decomposing the “source” signals (NTAL and HYDL)? Wouldn't a component from the GNSS decomposition represent the NTAL signal? Or the HYDL signal? And then why do you combine NTAL IC1 and HYDL IC1 and compare them to the GNSS IC1? This implies this component is a portion (and only a portion) of two very different sources. How do you know that's all that's in there? I suppose, what I'm asking is some further clarification in the text about (1) what the different components actually mean in terms of “sources” insofar as are they “sources”? or just spatially independent signals/temporally independent and thus could be heavily influenced by certain things but not necessarily the entire signal (2) further explanation for the motivation behind decomposing the source signals (NTAL/HYDL) and why it's necessary. I realize some of this is not specific to this paper but ICA in these applications in general but I think the text would greatly benefit from further explanation.

Decomposition of the NTAL/HYDL

The spatial pattern of the different components from the NTAL and HYDL are incredibly similar. Is this due to how the algorithm works or are these signals just by coincidence showing very similar spatial patterns. How much of the variance does each of these components represent? I think including that, maybe even just in the figures would be helpful for interpretation of the different components.

Temperature

I agree that the fourth component is well correlated with temperature. However, temperature is just a strong seasonal signal so couldn't this signal be something else? In lines 369-370, you mention that when temperature increases the stations in the mountains subside. I'm just confused by what physical mechanism would cause this. The two mechanisms that you list for temperature in lines 505, don't explain why the mountains would experience downward deflection during warm periods. Can you provide further explanation for the physical cause of this? I think in the paper you indicate too heavily that this component is due to temperature fluctuations (especially in Figure 8 and the associated text, the conclusion and abstract) and don't necessarily support this. Correlation does not always indicate causation. I think further data and text is needed to support this finding. Especially since this is mentioned in the abstract (line 16) as well as the conclusion (line 586/593).

Application of vbICA for removing NTAL and HYDL

Martens et al 2020 (J. of Geodesy) highlighted the importance of removing NTAL and NTOL signals from GNSS timeseries to reduce scatter/dispersion. In lines 351-353, you mention, vbICA may not be able to separate the NTAL vs HYDL signals. Why not just remove the signals using the GFZ products instead of using the ICA method? Does removing the ICA reduce the scatter more than just removing the signals to begin with? -

Minor comments:

GNSS processing - Do remove signals due to earthquakes? In the supplement you mention removing offsets due to equipment changes but don't mention offsets or post seismic signal removal. Does the ICA capture earthquake signals? Wouldn't this be a good signal to remove to better isolate the uplift?

Line 123: grammatical issue - "Since they allow to account"

Line 254: grammatical issue - "its temporal evolution has not a domination frequency"

Lines 230: What reference frames are you using for the NTAL and HYDL models?

Lines 250-251: There are no units for y-axes on the temporal portion of the components. What are the units? Are there any? To construct the signal at a given spot, do you multiply the temporal by the spatial displacement for that point? It would be helpful for understanding the figures.

Lines 340: For the second component, you list Pearson's correlation coefficient in addition to the Lin's. Can you list the Pearson's for component 1? And in the third component, is this the Pearson's or the Lin's coefficient?

Line 338: How many stations have displacements above 3mm?

Line 389: Is the k value -2 for both?

Line 404-408: I think there's a typo here.

*Consequently, the **unfiltered** time series are modeled only with the linear trend plus the temporal correlated noise, while the **unfiltered** time series modeling annual and semi-annual terms are also included.*

Are both unfiltered? I think the first one should be filtered, yes?

Section 5.3: If you are removing the linear trend, then are your uplift rates non-tectonic uplift? Or are you adding that back in? Just confusing since in the introduction it seemed like you were settling up to better estimate uplift rates due to tectonics? I think it's fine to remove the linear trend for comparison of stacking methods ect but for Figure 13 and discussion in 5.3 is this with the linear trend removed or included? I the nontectonic uplift? Or are you adding the linear trend back in? Can you clarify?

Many of the figures appear blurry. Additionally, the font on the axes of many of the figures is incredibly difficult to read (eg Figure 3) and would benefit from larger font size.