

Interactive comment on “Channel selection method for hyperspectral atmospheric infrared sounder using AIRS data based on layering” by Shujie Chang et al.

Anonymous Referee #4

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General Comments

The paper by Chang et al. introduces a channel selection method for infrared hyperspectral sounders. A particular feature of the method proposed here is that it takes the height dependencies of the kernel functions into account. It is shown that this approach reduces AIRS temperature retrieval errors compared to other methods.

The study has interesting findings, but I found the presentation quality of the manuscript to be rather poor. I would like to ask the authors to please carefully address the numerous specific comments and technical corrections, so that the paper becomes suitable for publication.

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Specific Comments

I1-3: I would like to suggest to streamline the title a bit, e.g., "A channel selection method for hyperspectral atmospheric infrared sounders based on layering". Perhaps the reference to the AIRS instrument can be neglected in the title as the method will be applicable to other instruments, too?

I22-24: The statement "The distribution of the temperature weight function is more continuous, more closely approximating that of the actual atmosphere" is unclear to me. Do you mean the coverage or sensitivity of the weighting functions is more evenly distributed over height with this method?

I28: The term "near space layer" is not commonly used, I think. I would suggest to rephrase it by "stratosphere and mesosphere" here and in other places of the manuscript, for clarity.

I31-35: The acronyms ICS, NCS, and PCS need to be introduced in the abstract.

I50-55: The word "detection" is frequently used in the manuscript, but considering that you are referring to temperature, I would recommend to change this to "sounding", "observation", or "measurement" in most instances.

I61-62: Can you add a more recent reference regarding "today's needs" of NWP? Eyre et al. (1993) is more than 20 years old.

I70-72: IASI became operational in 2007 and not in 2010.

I129-130 and I140-142: Which instruments are you referring to here? AIRS has more than 2000 channels.

I147: I would suggest to rephrase "weight function" by "weighting function" here and throughout the manuscript.

I147-148: The statement "... use only the weight function to study appropriate numerical methods, the use of which allows sensitive channels to be selected." is unclear to

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me. Please rephrase.

I155-161: The concept of information content itself does consider all the height dependencies of the kernel matrix K (Rodgers, 2000 or Eq. (1) in the present manuscript). Earlier work may have neglected the height dependencies of K for simplicity and to ease the calculations. These sentences should be rephrased so that they do not give the wrong impression that the information content ignores the height dependencies of the weighting functions in general.

I195-195: This is redundant and can be deleted.

I216-219: This sentence is unclear and should be rephrased.

I221-227: The "sequential absorption method" has been described elsewhere before, e.g., (Dudhia et al., 2002):

Dudhia, A., Jay, V. L., & Rodgers, C. D. (2002). Microwindow selection for high-spectral-resolution sounders. *Applied Optics*, 41(18), 3665-3673.

I231: The expression " $\partial^2 \Omega / \partial \nu^2$ " has not been explained and the derivative looks wrong, maybe skip it here?

I262-263: The sentence "According to S_a, S_\epsilon...can be calculated" is unclear and should be rephrased.

I271-275: I would suggest to remove the phrase "... but it still satisfies the optimum value in a certain sense". The method cannot find the global optimum as it applies only a sequential search strategy. It is good to point out this limitation, no need to oversell the results.

I283-285: I did not understand how you are actually making use of the different channel selections for the different heights in the retrieval process. Does this mean the different channel sets are used to evaluate only certain heights in the retrieved profile?

I330 and 344: I got confused about the notation, what is "\hat T" referring to?

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I379-380: "after retrieval of observations has been complete several times" is unclear to me.

I380-383: How do you deal with non-linearity inherent to atmospheric radiative transfer? Isn't that a major problem for multiple regression?

I387: Add a reference for the AIRS instrument, e.g. (Aumann et al., 2003).

I395: The AIRS footprint size 13.5 km at nadir, please check.

I396-398: 4.3 and 15 micron are used simultaneously for both, temperature and carbon dioxide retrievals, I think.

I398: When you refer to "absolute accuracy", does this include noise as well? Noise should not be included as it counts as "precision".

I399-401: "the four imaging channels of visible/near infrared are always filled" is unclear, please explain or remove.

I406-411: This paragraph can be deleted. Everything was already said in the introduction.

I412: Does the "root-mean square error" include both, accuracy and prediction, in this study?

I416-417: Delete the sentence "Moreover, not all channels possess the same measurement error." This is obvious from the figure.

I415: Please provide a reference or a web link for the RMS errors shown here.

I429: Introduce acronym and provide reference for RTTOV.

I429-430: Delete sentence saying "RTTOV is an evolution of..." as this does not provide really useful information.

I431: What is ATOVS?

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I440-443: Table 1 is not needed at all in this manuscript, I think. What is the reader supposed to do with it? Just provide the web link for reference.

I451-452: The phrase "The weight function matrix K ..." can be deleted, as this is clear.

I465: What is H(X0)? Is it needed for anything here?

I473-475: Which "products" are you referring to? Is there a reference for the NWPSAF requirements?

I492-495: At this point the reader does not know anything about the IFS-137 data set. It is introduced much later in the manuscript.

I500: What is causing the off-diagonal bands in the temperature covariance matrix? For instance, why is the temperature at 100 hPa closely correlated with temperature at about 60-70 hPa?

I516: The color bar unit is "K^2", but shouldn't this be "K/K", as it refers to a change of brightness temperature with respect to atmospheric temperature, i.e., dB/T/dT? (same for Fig. 7)

I532-544: Wavenumbers are missing the unit "cm^-1". Replace "11 micron" by "10 micron".

I546: The term "high temperature zone" is used here and elsewhere in the manuscript, but what does it refer to? Please explain.

I575-576: "Moreover, the temperature profile of each layer can be retrieved." How can you retrieve a profile for a layer? Please clarify.

I569 and 583: Figs. 5 and 6 could be combined in a single figure to allow for a comparison.

I596-605: You are describing the PCS distribution as "scattered", but I would rather apply this word to the ICS distribution. The ICS distributions seems to jump or scatter

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from one iteration to the next. The PCS distribution looks much more continuous along the x-axis.

I604-605: Sorry, but I don't know what you mean by "scenario in the real atmosphere" in this context?

I615-619: Please provide a reference for the IFS-137 data set here.

I620-623: Please replace the number of model grid points by something more meaningful such as horizontal resolution of the data. The list of the 137 individual pressure levels and Table 2 are not really needed, I think.

I647-664: As you are not going to make any use of the IFS-91 data set in this study, there is no need to introduce it and discuss the differences with respect to the IFS-137 data set. Section 4.1 could be shortened significantly, I think.

I641: The axes labels in Fig. 8 are too small.

I658: Fig. 9 is not really needed, as it was already pointed out in the text that the coverage of the IFS-137 data set is rather homogeneous.

I674: Why does the RTTOV model need 10 m wind speeds for the radiative transfer calculations?

I744-746: Did you also look at the southern hemisphere polar regions? The sentence "These regions' profiles can represent the global typical atmospheric temperature profiles" makes no sense to me because the regional means are different from the global mean. Delete this.

I746-748: I got very concerned about the mean temperature profiles shown in Fig. 11. If these are regional means of hundreds to thousands of profiles, how can they show wave oscillations and look that noisy? Shouldn't the mean profiles be rather smooth? Is this due to the original selection of the IFS-137 profiles focusing on cases with strong temperature gradients?

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I774-775 and 813: It is okay to say that ICS works "better" than NCS or PCS, but saying it is "greatly superior" or "impressive" is overselling the results, I think. Suggest to rephrase this and use more moderate wording.

I819-834: Tables 4 to 7 are largely redundant and can be removed from the paper, I think.

I849 and 882: Suggest to simply delete the headings for Sects. 6.1 and 6.2, as they appear in the wrong order. The conclusions should follow the discussion.

Technical Corrections

I30: remove "evidently"

I38-39: suggest to rephrase "... is feasible and shows great promise for application" as "... shows potential for future applications"

I44: _the_ Earth's

I67-68: suggest to rephrase "AIRS has 2378 spectral channels with subpoint at 13 km and a detection height from the ground of up to 65 km" as "AIRS has 2378 spectral channels providing sensitivity from the ground to up to about 65 km of altitude"

I73: change "attaches" to "devotes" (or similar)

I76: change "detection" to "observations" (or similar)

I80: change "atmospheric detectors" to "instruments"

I83: delete "intense"

I86: change "general satellite detection instrument" to "typical satellite instruments"

I89: change "the center frequency, bandwidth" to "center frequency and bandwidth"

I96: there is _often_ a close correlation between _the channels_

I106: demands of _simulating_ all the channels

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I107: to _properly_ select

I151: ignoring _some_ factors

I183: change "\hat S" to "S_\epsilon"

I186: delete "by hyperspectral data"

I187-188: delete "which comes from the selected channel in hyperspectral data with respect to ..." or rephrase to clarify

I209-210: rephrase to "... combination making the information content..."

I235: change "single" to "scalar"

I242: rephrase to "Since S_a and S_\epsilon are ..."

I248: change "pre-observation error" to "a priori uncertainty"

I275: delete "its"

I288: method_s for_ the ... profile_s_

I297: _numerically_ stable

I302: change "bright temperature" to "brightness temperature" (here and throughout the manuscript)

I303: expanded _as_

I367: Taking a derivative of Eq. (21) with respect to G,...

I387: delete "instrument suite" and change to "is _primarily_ designed"

I415: few _channels_

I428: rephrase to "For the calculation of radiative transfer and the weighting function matrix, K, the RTTOV..."

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I434: rephrase to "and _trace_ gas concentration_s_"
I439 and 440: delete "v12"
I459 and 461: change "characteristic" to "variable"
I460: delete "radiation"
I481: selection __ in
I491: rephrase to "...of the AIRS channels"
I510: change "But due to" to "However,"
I518: delete "of ICS"
I563: change to "retrieval of temperature"
I611: was used _for the statistical inversion experiments_.
I675: mode_l_. Then, the _simulated AIRS spectra are_ obtained
I696: delete "obviously"
I704 and 719: _at_ different height_s_
I729: change "impressive" to "improved"
I740: change "weather conditions" to "atmospheric conditions" (also elsewhere in the manuscript)
I743: change "and divides it" to "have been divided"
I777: replace "optimized to" by "improved by"
I785: (_d_) Arctic
I892: _is_ proposed

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