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Atmospheric Measurement Techniques Discussions

Interactive comment on "Towards IASI-New Generation (IASI-NG): impact of improved spectral resolution and radiometric noise on the retrieval of thermodynamic, chemistry and climate variables" *by* C. Crevoisier et al.

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First, we would like to thank the referee for their constructive comments. The answers to their comments are listed below.

Overall comments

IASI-NG is an important new instrument and therefore detailed evaluation of its potential and limitations is much needed and of high scientific significance. This

paper addresses its potential very well, but does not discuss limitations. Its natural to focus on the potential gains of IASI-NG but some discussion of the limiting factors, mostly arising from the very large field of view, needs to be added. It is for this reason I have marked scientific significance as good, but scientific quality only fair, because as it stands someone unfamiliar with infrared remote sensing could misintrepret the wider significance of the results. I do not believe it was the intention of the authors to mislead anyone, but because these issues are not even mentioned I think there is a high risk of this outcome. There were some errors in presentation but overall it was well written and clear, so I have marked the presentation as good.

I am recommending for acceptance with minor revision because the paper does make a significant contribution and will be of wide interest. This is because I do not think my concern, although major, requires anything more than a short addition to the paper to acknowledge the field of view size issue, and its implications for scene heterogeneity, and the relevance of this to cloud screening / analysis and near-surface sounding. The paper lacks a discussion whether IASI-NG's spectral resolution and lower noise will improve these aspects. Almost certainly it will not, or only marginally compared to smaller fields of view. Many people think this was a missed opportunity going from IASI to IASI-NG so it does need to be openly discussed. The leading scientific Working Group on infrared sounding, the ITWG, has been calling for years for smaller field of view sizes for infrared sounders. Clouds are the biggest issue to solve with any analysis of IASI-type data, so this must be discussed, even if other field of view size aspects (e.g. for the land) are not. I am calling this minor revision, but I do not think the paper should be accepted unless it is added, because it is very important.

We agree with the referee that there is always a trade-off in deciding how to increase the performance of an instrument. In our case, increasing the signal to noise ratio, improving the spectral resolution or diminishing the pixel size were all

possible options. As stated in the introduction of the paper, *'The improvement of both spectral and radiometric characteristics has been preferred to an improvement in the spatial resolution of the instrument (EUMETSAT, 2010).'* This decision was taken by the Post-EPS Mission Expert Team after the consultation of the various scientific communities involved in the exploitation of the IASI instrument. The importance of reducing the noise has also been highlighted by a recommendation of the ITWG '*to improve the radiometric noise of post-IASI in the 4 micron band, by at least a factor of 2, without degrading the spectral resolution* ' (report available at http://cimss.ssec.wisc.edu/itwg/itsc/itsc16/presentations/13_02_ClimateWG.pdf).

Some studies performed by groups involved in IR sounders, especially within the IASI/IASI-NG Sounding Science Working Group have indeed shown that reducing the size of the FOV could help in getting more clear-sky situations and more homogeneous scenes. However, the current size reduction that needs to be achieved to increase significantly the number of clear-sky pixels is still under debate. Moreover, reducing the pixel size would increase the radiometric noise and thus degrade the improvement in both precision and vertical coverage that is foreseen with the scenarios studied here. An analysis of the pros and cons of reducing the pixel size is worth studying in details but is clearly beyond the scope of this paper, as the studies reported here aimed at quantifying the impact of improving both spectral and radiometric specifications on the retrieval of several atmospheric and surface variables in clear-sky situations, all other instrumental specifications being the same.

We acknowledge the fact that this needs to be clarified in the paper and thank the referee for suggesting it. The following sentences have been added to the introduction: *To fulfil these goals, IASI-NG will measure infrared radiation emitted by the Earth with improved spectral resolution and radiometric noise as compared to IASI.* The spatial resolution of the instrument will be the same as for IASI (EUMETSAT, 2010), following the recommendation of the Post-EPS Mission Expert Team for answering the needs of NWP, chemistry and climate applications. In particular, the size of IASI-NG field of view

will be the same as for IASI (about 12 km at nadir).

And the following paragraph has also been added to the conclusion:

It is worth noting that the impact of decreasing the size of the field-of-view as compared to IASI has not been studied here, following the specifications of IASI-NG defined by CNES and EUMETSAT (EUMETSAT, 2010). On the one hand, reducing the size of the FOV would allow getting more clear-sky situations, and thus potentially increase the number of observations used in NWP systems or in retrievals. It would also help getting more homogeneous scenes. On the other hand, reducing the pixel size would increase the radiometric noise and thus degrade the improvement in both precision and vertical coverage that is foreseen with the scenarios studied here. It would also impact the homogeneity of long-term climatologies of several ECVs derived from previous IR sounders (TOVS, ATOVS, AIRS) which had the same size of the FOV than IASI and IASI-NG. A combined study focusing on determining the impact of a reduction of the FOV size, along with associated change in spectral and radiometric characteristics, on the capability to retrieve atmospheric and surface variables remains to be performed.

Why is this study limited to the tropics? IASI-NG will go into a polar orbit, not a low inclination orbit, so will provide data at all latitudes. Why do you choose only to study the potential in the tropics? Are your conclusions applicable in other areas and if you say "yes" how do you know this?

The study has been done for all type of airmasses: tropical, mid-latitude, polar. In order to limit the number of figures, we have shown results obtained in the tropics for the channel sensitivities since the signature are the most visible there. Sensitivities obtained in the temperate and polar regions will be provided as supplementary materials. The gain in precision and vertical coverage is similar for all cases. This has been specified in the text.

The guidance asks me to consider some specific questions (starting with "Does the paper address relevant scientific questions within the scope of AMT?". The

answer to all these questions is yes.

Now some specific points

p11222 paragraph 1: "A negative sensitivity for a gas ...." Where an increase in gas increases the BT then this is a positive sensitivity (as tends to be the case in the stratosphere). The text needs correcting.

The sentence now reads 'a negative sensitivity for a gas indicates that an increase of the gas concentration induces a colder BT, and thus a channel mostly sensitive to tropospheric variation of the gas concentration'.

p11222 reference to Figure 2: Figure 2 seems to have a misplaced additional curve, in pink, which could well be aerosol, mostly evident in the LW between 800 and 1200 um. This just looks like a mistake, its not referred to in the legend or text. Either remove it or say why its there and correct legend.

The additional curve in dashed pink has been removed from Fig.2a.

p11224 equation 4: You do not say what you assumed about Smodel. Is it important, what did you do?

Smodel has been chosen diagonal with a standard deviation of 0.2 K. This representation of forward model noise is not realistic and attention needs to be paid to improving our knowledge of this error. Nevertheless, this value has been widely used in previous publications (Rodgers 1996; Prunet et al. 1998 ; Crevoisier et al. 2003), and does not impact the values of the gain in uncertainty and vertical coverage reported here, since results are presented relative to each other.

p11225 paragraph 2: You confirm near surface retrievals is a priority for IASI-NG. This makes the comment above about field of view size even more important.

Sea above. With the same size of the field of view, the improvement of spectral resolution and radiometric noise improves the near-surface retrieval, despite not providing

more clear-sky situations.

p11226 reference to Figure 3 for noise. Figure 1 shows the noise much more clearly, its hard to see in Figs 1-2 which are very busy.

Figure 1 displays the noise at a reference temperature of 280 K throughout the spectrum, whereas Fig. 2-3 display the noise at the BT of the scene which is the relevant noise to consider while comparing with the channel sensitivities.

p11227 reference to Figure 4. Why not show averaging kernels here as this would show if the spectral resolution gain actually improves analysis potential? You already explained why AKs are better to look at, then don't!

Each section has been divided in two sub-sections: the first one is devoted to the radiative part (forward simulations) whereas the second one deals with the retrieval technique (inverse models). Figure 4 deals with Jacobians and thus belongs to the first subsection. It shows clearly what can been expected from the measurements themselves, and their given spectral resolution, prior to any inversion of the radiances in terms of temperature. Averaging kernels would show the improvement brought by both spectral resolution and radiometric noise. This is why we have favoured Jacobians here. Averaging kernels are mode widely used for atmospheric composition studies, hence their use for the subsections dealing with CO, O3, etc.

p11228 Given this is averaged over a large database of tropical profiles I can not understand the discontinuity in information at 900hPa. Is this because the background error variances changed abruptly at this height? Was your B appropriate to the region you are studying?

The covariance matrix used here comes from ECMWF and is given by air mass type. The strong reduction in the relative gain in error comes from the fact that the retrieval of temperature profile is done independently from the retrieval of surface temperature, and reveals the lack of information brought by IR sounders in the lowest vertical layers

apart from window channels informing of surface temperature. This clarification has been added to the text.

p11229 I am not clear whether the near surface benefits here arise from the better characterisation of the surface described later (Figure 10) or whether this aspect and the direct line resolving capability are being considered in isolation. But I am assuming the latter. I think if the surface can be characterised better this is very important for near surface sounding as surface characterisation, at least over land, is a limiting factor. Its why so little IASI is used operationally over land at the present time. It does not matter what your line resolving capability is if you can't use the data at all! But if this helps you characterise the surface, and use more data, its potentially becomes very important. These aspects are not particularly well discussed here or later when Figure 10 is presented.

As said in the previous comment, the retrieval of atmospheric temperature and surface temperature are treated separately. So the referee's assumption is correct. This has been clarified in the paper. The importance of getting better resolution near the ground and at the surface is stated clearly in the introduction and is one the 3 objectives of the IASI-NG mission.

It should also be noted that another major reason why so little data is used over land is the impact of surface uncertaintly on cloud screening / analysis. As ever with IR sounders clouds is the big issue! The big issue that this paper ignores!

See above.

p11230 onwards. Lots of detail here which is fair enough, as its covering many species and examining each in detail. No specific comments, but although its a tiring read to take it in one go, I think its a useful reference work and the length is justified.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 11215, 2013.