We thank the reviewers for their constructive criticism on our manuscript. We have responded to all comments made by the reviewers as the text below shows. The answers are structured as follows: (1) comment of the referee in **black**, (2) answer in **red** and (3) rewritten text parts in **blue**.

Anonymous Referee #1 / Received and published: 24 October 2015

Specific Comments

1. The major issue I have is that the authors assume an IG TTD, and attributes differences between model and data to sub or super saturation of the tracers (or SF6 remaining from deliberate tracer release. However, another reason (that I think is more likely)is that the TTD is not well described by a single IG TTD. The authors need to explore this possibility. In the Stoven et al. (2015) they did some calculations using two-IG TTDs, and I think similar calculations need to be done here. Is it possible to reproduce the SF6 and CFC12 using a two-IG TTD, and if so how different is the calculated Cant?

Our assumption on saturation effects opens up new perspectives on possible error sources when using ocean ventilation models at high latitudes. So we do not know yet if saturation effects or complex mixing processes are responsible for the specific concentration ratios of transient tracers in these ocean areas. The problem is that the system of equation of the 2IG-TTD is undetermined due to the five free parameters (two "Deltas", two "Gammas" and the ratio between the two water-mass abundances alpha) combined with only two transient tracers. Nevertheless we did some calculations using the 2IG-TTD which are shown in the figure below. Here we used the same assumptions as in Stöven et al. (2014) since it incorporates one very advective (Delta/Gamma=0.6) and one more diffusive water parcel (Delta/Gamma=1.4). It can be seen that most of the data points are still outside the application range unaffected by the alpha-parameter.

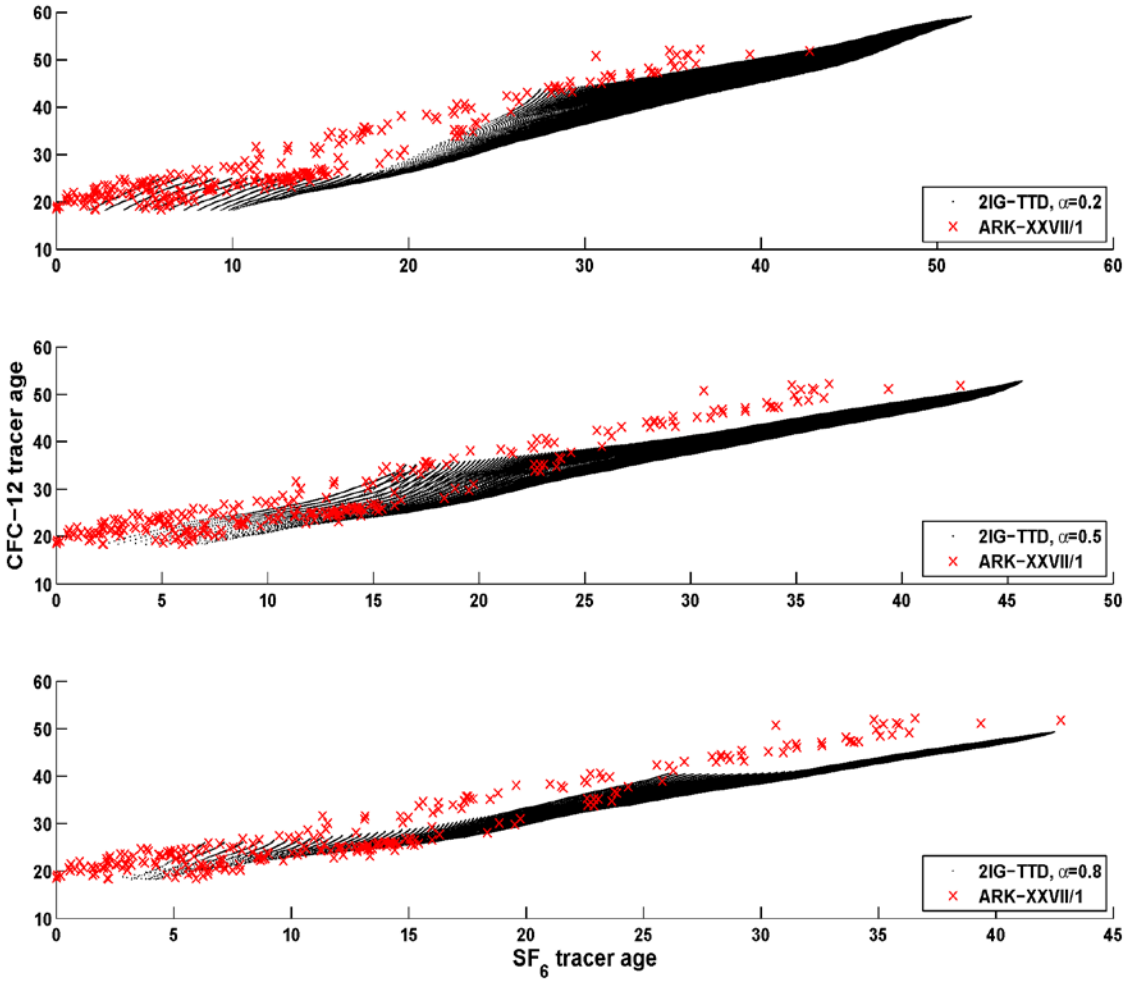
Section 2.3

"Another approach is based on a linear combination of two IG-TTDs which can be used to describe more complex ventilation pattern (Eq. 3) (Waugh et al., 2002). The variables of this model are $\Delta_{1,2}$ and $\Gamma_{1,2}$ of the two IG-TTDs and α which describes the ratio between both distributions. The main problem of applying this method is, that five free parameters need to be determined. Hence, this model combination can be constrained with five transient tracers with sufficiently different input functions. Alternatively, predefined parameters can be used (Stöven and Tanhua, 2014)."

Section 3.3

"Another approach is provided by the linear combination of two IG-TTDs. Since we only have the data of two transient tracers, we used the same predefined parameters as described in Stöven and Tanhua (2014) which includes one more diffusive water parcel (Δ_1/Γ_1 = 1.4) and one very advective water parcel (Δ_2/Γ_2 = 0.6). Figure 6 shows, similar to Fig. 5, the validity area of the linear combination of two IG-TTDs for different α of 0.2, 0.5 and 0.8. Although this combination describes several scenarios from highly advective to diffusive mixing of two distributions, it can be seen that most of the observed data points are still outside the validity area. Thus, the tracer age

relationship between CFC-12 and SF_6 can neither be described by the IG-TTD nor a linear combination of two IG-TTDs."



2. The discussion in first few sentencing of section 2.3 uses "transit time distribution", "Green's function" and "age spectra" somewhat interchangeably, which is confusing. I think they mean the same thing for all 3 terms and should just use one. If they mean different things by each term then they need to describe this better.

Text part rewritten.

Section 2.3

"A transit time distribution (TTD) model (Eq. 1) describes the propagation of a boundary condition into the interior of the ocean and is based on the Green's function (Hall and Plumb,1994). Here, c(ts;r) is the specific tracer concentration at year ts and location r, c0(ts -t) the boundary condition described by the tracer concentration at source year ts-t and G(t) the transit time distribution of the tracer. The exponential

term corrects for the decay rate of radioactive transient tracers. Equation 2 provides a possible solution of the TTD model, based on a steady and one-dimensional advective velocity and diffusion gradient (Waugh et al., 2003). It is known as the Inverse-Gaussian transit time distribution (IG-TTD) where G(t) is defined by the width of the distribution (Δ), the mean age (Γ) and the time range (t)…"

3. There is no discussion of application of SF6 as age tracer. Although CFC12 can't be used in "young" waters, SF6 can.

Additional text added.

Section 2.3
"Note that the use of CFC-12 as transient tracer is limited to concentrations below the recent atmospheric level since the production of CFC-12 was phased out in the early 1990s so that the depletion rate exceeds the emission rate since the early 2000s. This causes indistinct time information of CFC-12 since one concentration describes two dates in the atmospheric history. To this end, the use of CFC-12 is restricted to water masses with concentrations below the current atmospheric concentration limit. The emission rate of SF6 still exceeds the depletion rate so that the atmospheric concentration is still increasing. SF6 thus provides distinct age information of water masses over the complete concentration range."

4. On page 2203 evidence is presented that suggests that the "excess SF6" is not due to deliberate tracer release, but on pg 2208 (line 29) this is given as one of the reasons. I am confused, do the authors think this is a likely cause? If not then should not be in the conclusions.

We think that both sources of excess SF_6 play a role in the Nordic Seas and Arctic Ocean. The ratio between natural and anthropogenic supersaturation cannot be determined by the data at hand. However, compared to the observations in the Southern Ocean, we think that natural supersaturation by bubble effects can have larger impacts than previously thought. The text might have been misleading in this case and was rewritten to clarify this crucial point.

Section 3.4
"One possibility refers to the deliberate tracer release experiment in 1996 where 320kg (~2190mol) of SF6 were introduced into the central Greenland Sea (Watson et al., 1999). (…) However, CFC-12 and SF6 data of the Southern Ocean (Stöven et al., 2015) shows similar tracer age relationships compared to the Fram Strait data but with no influence of deliberately released SF6. This indicates that another source of excess SF6 may exist which is much larger than the source of the tracer release experiment."

Section 4
"We assumed that the different tracer age relationships are due to different saturation effects on the tracers during water mass formation and still existing offsets of the SF6 concentrations caused by the deliberate tracer release experiment in the Greenland Sea in 1996."

5. Should the Stöven et al. (2014) references on pg 2203 be the 2015 paper?

Yes indeed. Reference corrected.

6. "is supposed to be" indicates that the authors don't think this is the reason. If they authors think the applicability is limited because of these factors then remove "supposed to be".

Yes, we do not think that complex ventilation pattern are limiting the application of the model. However, ventilation models are always based on restrictive assumptions and only provide a simplified view on natural processes. The question is, if the model is too far away from reality or if other circumstances such as saturation effects lead to wrong assumptions. Here again, the text was rewritten for a better understanding.

Section 3.8

"We showed that neither the IG-TTD nor linear combinations of the model can describe the tracer age relationships between CFC-12 and SF6 in the Fram Strait. This means that either the models are not suitable to describe the prevailing ventilation pattern or that there are other reasons which lead to the specific concentration ratios. Here we focused on the second case which incorporates the assumptions that the tracer age relationships are related to different saturation states of the transient tracers and, furthermore, that the simple IG-TTD model can describe the ventilation processes of all water masses in the Fram Strait. The uncertainties of our approach thus correspond to the chosen shape of the IG-TTD, i.e. the unity ratio of Δ/Γ = 1.0, and the uncertainties of the measurement precision of the transient tracers and apparent transient tracers (see section 3.6 above). Further uncertainties are related to processes which influence the gas exchange and thus the boundary conditions of the tracers. This includes the important but yet rarely investigated impact of sea ice cover, sea ice formation and sea ice melting processes as well as bubble effects during heavy wind conditions."