Review 1

Dear reviewer,

Thank you for your careful review of our paper. We have mostly made all the corrections requested for the text and the figures as explained below in blue. Changes are tracked in red in the revised version of the manuscript.

Abstract:

- suggest rephrasing "present-day phenomena such as squall lines..." as it suggests that a squall-line is something unique to present day

We have removed “present-day”.

- the abstract would benefit from more specifics regarding what type of model is presented in the paper: single-moment mixed-phase bulk, kinetic fractionation considered, deuterium and oxygen-18 isotopologues tracked, …

Details about the implementation of the water stable isotopologues in the model have been added in the abstract: “With this motivation, we implemented water stable isotopologues ($HD^{16}O$ and $H_2{}^{18}O$) in the non-hydrostatic mesoscale atmospheric model Meso-NH and its one-moment bulk mixed-phase microphysics scheme. The water stable isotopologues are subject to the same dynamical and physical processes as the light water, but are subjected to isotopic fractionation during water phase changes. Both equilibrium and kinetic fractionation processes that occur during water phase changes involving water vapor are taken into account.”

Section 1:

- despite defining isotopic delta only in eq. (9) - 5 pages later, it is already used on page 1/line 11, suggest rephrasing to (deuterium and oxygen-18)

This is done.

- line 25: "So far, modeling studies have relied on models with parameterized convection" seems to contradict later statement on existing cloud-resolving models or large-eddy simulation models

We agree. We have reformulated as follows: “A large number of modeling studies…”

- line 31: worth mentioning as well the DESCAM isotope module: Hiron & Flossman 2020 (DOI:10.1029/2019JD031753) and commenting on the type of microphysics description employed in each model (single-moment, multi-moment, bin; liquid- vs. mixed-phase, which isotopologues tracked, ...)

The reference to Hiron and Flossman (2020) has been added in the introduction, and the microphysics of the cited models has been developed: “The DHARMA cloud model integrates the evolution of HDO within a bin microphysics scheme explicitly representing cloud condensation nuclei, water droplets, and ice crystals using 16 mass bins, as described by Smith et al. (2006). The 2-moment bin mixed-phase microphysics scheme DESCAM has recently been extended to simulate the evolution of oxygen-18 within a 1.5D dynamical framework (Hiron and Flossmann, 2020). Such bin microphysics schemes are undoubtedly an advantage for accounting for different isotopic compositions depending on particle size, but it comes at a very high computational cost. Thus, DHARMA and DESCAM typically track only one water stable isotopologue in addition to light water species. On the other hand, numerical models employing bulk microphysics schemes usually simulate the evolution of both $HD^{16}O$ and $H_2{}^{18}O$. This includes models such as SAM-ISO (Blossey et al., 2010), COSMO-ISO (Pfahl et al., 2012), WRF-ISO (Moore et al., 2016), and, more recently, NICAM-WISO (Tanoue et al., 2023). All these models incorporate the evolution of the two isotopologues into a one-moment bulk microphysics scheme. The microphysics schemes in SAM-ISO, WRF-ISO, and NICAM-WISO typically describe the evolution of water vapor, cloud water, rain, cloud ice, snow, and graupel mass. However, graupel is not considered in COSMO-ISO."

- line 41: typo: "third", not "thirst"

We apologize for this typographical error. This is corrected.

Section 2:

- first paragraph: among the 17 literature references provided for Meso-NH, several have no relevance for the presented development, suggest referring to references given within Lac et al. 2018, and focusing in this paragraph only on the model components which have further usage in the text;

You are right, there are probably too many references in this paragraph. However, this overview of the model intends to show its capability to simulate a large range of atmospheric phenomena with a large set of physical parameterizations. Even if convection, aerosols, radiation and surface processes are not considered in this study, we think it is important to mention the capacity of the model for future applications of Meso-NH-ISO. On the other hand, we agree that the chemistry and electrical schemes are not necessary here. The paragraph has been modified accordingly.

- line 60: does the per-mass-of-dry-air definition also apply to (specific) number concentrations?

In the ICE3 1-moment microphysics scheme, when the number concentration is used, the per-mass-of-dry-air definition applies. However, initial conditions and output variables for number concentrations are expressed in m^{-3} since it's more meaningful.

- line 69: use th instead of math mode to avoid italics

Done.

- line 89: would "ablate" instead of "decay" be a better suited word here? (see, e.g., DOI:10.1029/2019MS001689)

Done.

- line 93: this line needs elaboration as it is not understandable without getting acquainted with the referenced paper and it is unclear what "suppressed" implies here?

A short paragraph has been added to explain the main modifications in the ICE3 scheme to address time-step dependency: “To eliminate time-step dependency, key modifications include integration of heat budgets to constrain physical processes (e.g., melting) and to fix flawed calculations (e.g., snow-to-graupel conversion). Other adjustments include graupel growth modes (dry/wet), continuous cloud droplet shedding, and symmetric hail/graupel processes, reducing time-step biases. For large time steps (> 10 s), time-splitting enables more frequent process interactions. These changes significantly reduce time-step dependency with a modest computational overhead (see Appendix B in Riette (2020)).”

Section 3:

- despite the "implementation" in the title, there is no discussion of implementation in this section, it rather deals with model formulation, what about "Formulation of the Meso-NH-ISO water stable isotopologues model"?

We agree. We have reformulated the title as “Formulation of the Meso-NH-ISO water stable isotopologues”.

- line 98: suggest highlighting that the approach implies that enabling the isotopic fractionation dynamics does not alter any of the model results that would be obtainable with the fractionation disabled (IIUC)

We clarified this aspect as follows: “The introduction of water isotopologues in Meso-NH does not interfere with any of the model physics or dynamics. We checked that the model results before and after the introduction of isotopologues are exactly the same.”

- line 101: "duplicated twice" sounds like quadrupled, but here you get three entities, right?

We have clarified as follows: “In practice, each water variable for light molecule $H_2{}^{16}O$ is duplicated for heavy molecules $HD^{16}O$ and $H_2{}^{18}O$”.

- line 102: "tracked" or "considered" rather then "implemented"

“implemented” has been changed to “tracked”.

- eq. (7): nabla is missing

Corrected.

- line 105: the paper deals with 2D simulation, hence suggest omitting "3D" here

In this section we describe the model formulation. The model can be used for 1D, 2D or 3D simulations. So we keep the general 3D formulation here.

- line 108: "source species" sounds like referring to the source term, better "light species"?

We have changed as follows: "The mass exchange of heavy isotopes ... is proportional to their relative mass mixing ratio in the reservoir from which the flux comes from".

- line 118: VSMOW ratios are defined for atoms, not molecules, worth commenting on it (https://web.archive.org/web/20200729203147/https://nucleus.iaea.org/rpst/documents/VSMOW_SLAP.pdf)
- eq. (9): inclusion of the 1000 factor in the definition is misleading - this is just a unit for reporting the values; analogously, the definition of the mixing ratio is "m_v/m_d" and not "1000*m_v/m_d" even though you report it in g/kg; and rain rate definition does not feature 60 or 1000 multipliers for second-to-minute and meter-to-mm conversions; I am aware that this is common in hydrological literature, but still suggest just commenting that the common unit is per mille (see also eq. (1) in the above-linked IAEA Reference sheet); same for unit of d-excess in Table 2 (should be dimensionless) and delta units in Tables 3 & 4 (dimensionless).
- eq. (10): explain the "meteoric water line" concept, elaborate on the 8 factor (cf. page 14/line 316!) and refer to Craig 1961 (DOI:10.1126/science.133.3465.1702) where it was first given

We have reformulated the end of section 3-1 from line 116 following the 3 aforementioned suggestions. Note that we have removed the 1000 factor in the equation and mentioned in the text that delta is expressed in ‰. However, we keep this unit in tables as the delta are reported with this unit on figures and in the text.

- eq. (10): suggest using a short dash instead of "minus" for typesetting "d-excess"

Done.

- subsection 3.2: suggest highlighting the relation with vapour (super)saturation
- subsection 3.2.1: the handling of the Bergeron process should also be elaborated on here, and the implication for isotopic fractionation highlighted

To address these two issues, we have reorganized Section 3 to clarify which microphysical processes fractionate or not, why we assume that some processes do not fractionate, and to give more details on vapor saturation. Concretely:

- Section 3 now includes the following two subsections: “3.2 Non fractionating processes”, and “3.3 Fractionating processes”.
- We added a paragraph to discuss our assumption that the Bergeron process does not fractionate: “Concerning the Bergeron process (BER), we assume it does not fractionate. The Bergeron process is the evaporation of cloud droplets followed by the ice deposition in mixed-phase clouds, when the air is subsaturated with respect to liquid and supersaturated with respect to ice. Since ice deposition in supersaturated conditions is associated with kinetic fractionation, the Bergeron process is often assumed to fractionate (Ciais and Jouzel, 1994). When the Bergeron process is at play in convective updrafts, it acts to enrich the vapor and decrease its d-excess at altitudes above the 0°C isotherm (Bolot et al 2013). In ICE3, the mass transfer rate from cloud droplets to ice crystals, is assumed to equal the water vapor deposition rate onto pristine ice crystals, which in turn equals the cloud droplets’ evaporation rate. This keeps the water vapor reservoir neutral. Therefore, we ignore fractionation during the Bergeron process, as in Blossey et al. (2010). Due to this assumption, we may slightly overestimate the isotopic depletion and the d-excess in the upper troposphere. This is not an issue for science applications focusing on surface precipitation or low-level water vapor, but future refinements might be required for applications in the upper-troposphere.”
- The kinetic fractionation associated with supersaturation is now detailed in section 3.3.3: “Diffusional growth of ice hydrometeors”. The formula for the supersaturation over ice is now given.

- eq. (16): according to Table 2, D_v should be in SI unit m^2/s, but the value 0.211 yields a result in cm^2/s (it is correct in the code, see also a note code quality below)

You are right: 0.211 has been replaced by 0.211×10^{-4} in the text.

- eq. (23): the text above suggests that Pruppacher & Klett provided the isotopic formula, which is not the case, suggest simply referring to eq. (14) above or citing a work which covered isotopologue mass transfer (e.g., Gedzelman & Arnold 1994, DOI:10.1029%2F93JD03518)

To avoid any misunderstanding, we now refer to Eq. (14).

- line 206: "interact" -> "interacts"

This is done.

Section 4:

- line 223: suggest changing "fully observed" to "subject to comprehensive radar observations" (also in line 427)

We have changed the beginning of section 4-1 as follows: “We tested Meso-NH-ISO with a 2D simulation of a West African squall line that occurred during the night of 23 to 24 June 1981 in the northern Ivory Coast (5°37’W, 9°25’N). This tropical squall line was extensively observed by several radars, soundings and a network of surface observations as part of the COPT 81 field campaign (Roux et al., 1984; Chong et al., 1987; Chalon et al., 1988; Roux, 1988) and simulated in different 2D and 3D numerical experiments (Redelsperger and Lafore, 1988; Lafore and Moncrieff, 1989; Chang and Yoshizaki, 1993; Caniaux et al., 1994).”

- line 224: "simulated with ... numerical experiments" -> "simulated in ... numerical experiments" (?)

This is done.

- line 230: "short-live" -> "short-lived"

This is done.

- line 233: it is unclear if 40% concerns mass or number

Chalon et al. (1988) modeled water mass transport within the squall line. They estimated that a total rain amount at the ground should be 9.7 mm without evaporation in the stratiform region which is higher than the 6 mm of total rain amount recorded below the stratiform region, leading to an evaporation of about 40% in mass. We have clarified this aspect in the text.

- line 246: "open" contradicts "periodic", and this is important to define if the isotopes are simulated in an open or closed reservoir (also in the context of later discussion on lack of steady state in vapour isotopic composition)
- line 246: clarify if "no lateral advection" refers to Y dimension?

There were errors in the initial version of the manuscript. They have been corrected. As in Caniaux et al. (1994), we use open boundary conditions in the x-direction, meaning that there can be inflows and outflows of isotopologues. In this idealized case study, the large-scale field of water isotopologues is similar to the initial field (as described in the first paragraph of Section 4.2).

- line 251: elaborate on what are the implications of using a 3D turbulence scheme in a 2D simulation

You are right, this sentence is not clear. We meant to say that the horizontal and vertical turbulent fluxes were calculated in this simulation. It has been modified in the manuscript: “Vertical and horizontal turbulent fluxes are computed with the turbulent mixing length equal to the squared root of the grid mesh (Cuxart et al., 2000).”

- line 254: is "Steady-state" a good title for a section concluding that "isotopic composition of water vapor does not reach equilibrium at the end of the simulation"

Right! The title of section is now “Evolution of rain and water vapor isotopic composition along the 8-hour simulation”.

- line 263: "moist and" -> "moist air"

Actually, this is the verb. We have corrected it as “moistens”.

- line 276: the text suggests that there is information about ice in the figure, but given that "total condensed mixing ratio" likely sums all five non-vapour water species, it is hard to interpret the figure. Suggest plotting liquid and solid water separately, and adding plot with relative humidity wrt ice

The goal of Figure 4a was to visualize the cloud. We clarify it in the manuscript: “To visualize the cloud shape, Fig. 5a shows the cross section of the total condensed water (the sum of the mixing ratio of all hydrometeors) along the x-direction.” We also added a sentence in the caption of Figure 5 (formerly Figure 4): “The total condensed water mixing ratio is the sum of the mixing ratio of all hydrometeors (cloud droplets, rain, cloud ice, snow/aggregates and graupel).” The way the relative humidity is computed is also clarified in the legend of Figure 5: “The relative humidity is calculated for saturation over water for temperatures over 0°C, and for saturation over ice for temperatures below 0°C”.

- Figure 3: y-axis label should be "r_v" not "q_v" if it is consistent with the caption, otherwise the caption is inconsistent with the text, and the symbol tables need addition of specific humidity

You are right. “q_v” has been changed to “r_v” in Figures 3 and 4 (formerly Fig. S1).

- Figure 4 caption: "kJ" not "kj"

This is done.

- line 293: "Isotopic results" sounds awkward to me, and perhaps "Simulated isotopic composition of ambient vapour and rain water"?

As recommanded, we changed the title of this subsection: “Simulated isotopic composition of rain and water vapor after 6 hours of simulation”.

- line 312: "We also probably detect rain evaporation within downdrafts" suggests as if it was not possible to confirm, while running the simulation with a given process disabled should provide a clear way of confirming it. There are several features commented as occurring "probably" or "likely"; given the low computational cost of a 2D simulation, I expect that some of these are verifiable by exploring simulation results with the processes in question toggled on or off.

The suggested sensitivity experiment would be tricky to interpret. Without evaporation processes, the squall line simulation will be quite different. For example, we would not even have cold pools, and therefore no squall line organization, since interaction between cold pools and the convective shear zone is essential for the squall line organization (Rotunno et al. 1988). That is why we did not perform such an experiment.

In this section dedicated to the description of the results, we were actually too cautious. We now state that the results are consistent with what we expect from previous studies regarding the role of evaporation processes on the isotopic composition of water vapor. We also now mention at the end of Section 4.5.1 that evaporation processes are further analyzed in Section 4.5.3 and Figure 10 (where the use of evaporation tendencies allows us to see where rain evaporation occurs).

- line 344: "minima" instead of "minimums" (as with datum->data)

This is done.

- line 409: use "\Delta t" for the time step, not "dt"

Done.

Section 5:

- line 431: "non-isotopic steady state" is not clear (also line 434), please rephrase

This sentence has been rephrased.

- line 433: rephrase "region on development"

We have changed as follows: “....the stratiform region is developing.”

- line 436: "well captures" -> "captures well"

This is done.

Table 1:

- values for "c" and "C" are missing $\times$ symbols (3 occurences)

Done.

Supplement:

- Figures in the Supplement are raster graphics (screenshots) not suitable for publication

The figures in the Supplement are now in the same format as the figures in the manuscript.

- according to GMD guidelines (https://www.geoscientific-model-development.net/submission.html): "Supplementary material is reserved for items that cannot reasonably be included in the main text or as appendices." (videos, very large images, maps, CIF files, as well as short computer codes...). Please incorporate the supplementary figures into the main body of the manuscript, especially that these are repeatedly mentioned in the text and required to follow the narrative.

Figure S1 was initially given to illustrate the discussion in Section 4-3 about the non-isotopic steady state at the end of the simulation for water vapor phase. We did not believe it was necessary to interpret the results. However, you are right: the last paragraph of Section 4.3 relies heavily on Figure S1. Therefore it is now included in the manuscript (Figure 4).

Figure S1 (formerly S2) is identical to Figure 7 (formerly 6) but only shows absolute values for illustrative purposes. This figure is not needed to understand the simulated isotopic results. We decided to remove all the references to this figure in the manuscript. We just inform the reader that a figure showing the absolute values of these parameters is available in the Supplement.

Figures S3 through S7 are included solely to illustrate that similar conclusions can be drawn at a different point in the simulation. We decided to keep these figures in the Supplementary Material since they are not required to follow the narrative and are not repeatedly mentioned in the text.

Maths, symbols, nomenclature:

- the term "isotope" applies to atoms, while "isotopologue" to molecules, hence suggest replacing "Water stable isotopes" with "water stable isotopologues" (incl. the title and keywords)

This is done.

- number concentrations have a per-mass definitions in the paper, which contradict the common per-volume understanding of the term, "specific concentration" would be a better name

This is probably a misnomer. However, since the term number concentration is commonly used in the literature concerning the microphysical schemes of Meso-NH (e.g. Caniaux et al., 1994 ; Pinty and Jabouille, 1998 ; Vié et al., 2016 ; Taufour et al., 2018), and it is not a key point in this article, we decided to keep the term number concentration.

- use upright font for label-like non-value subscripts, e.g. ρ_a, not ρ_a, etc (D_v, k_a, L_s, L_v, m_r, N_c, N_r, r_c, r_r, r_v, R_c, R_i, R_l, ...)

Done.

- both "isotope ratio" and "isotopic ratio" terms are used in the paper, please unify, see e.g. https://list.uvm.edu/cgi-bin/wa?A2=ind2110&L=ISOGEOCHEM&P=R40040

We chose “isotope ratio”.

- it is unclear from the text if "total water" includes all isotopic species or only the light isotopologue?

Total water is only used in the caption of Figure 4 as “Total condensed water” and means that Figure 4a shows the mixing ratio of all condensed light water. There is no relationship here with water stable isotopes.

- semiheavy water is sometimes labelled as HDO, and in other instances as $HD^{16}O$, suggest unifying

We chose $HD^{16}O$, and modified the manuscript accordingly.

Code:

- the model name and version given in the paper title (Meso-NH-ISO v1.0) are not consistent with the code archive (MNH-V5-5-0), and are not mentioned at the linked website (http://mesonh.aero.obs-mip.fr/mesonh55); the code archive must include the same labelling as the paper title

The title of the Zenodo archive has been modified: “Meso-NH-ISO v1.0: Water isotope scheme in MesoNH-v5-5-0”.

- the Zenodo archive Barthe 2026 lists Creative Commons as license, but the CC licenses are not applicable to software (https://creativecommons.org/faq/#can-i-apply-a-creative-commons-license-to-software), and the contents of the archive and paper text indicate CeCILL-C license.

You are right. This error has been corrected.

- the text indicates that the Zenodo archive contains "complete code of Meso-NH v5-5-0 including the water isotope scheme", but Zenodo metadata indicate: "Fortran routines to be inserted in Meso-NH V5-5-0 to use the water isotope scheme."

The Zenodo metadata have been modified. Now it is consistent with what is indicated in the manuscript: “Complete code of Meso-NH V5-5-0 including Fortran routines to use the water isotope scheme.”

- the Zenodo metadata indicate three authors: Barthe, Francois and Vimeux; the reference entry in the paper lists just one

François and Vimeux were indicated as contributors in Zenodo metadata. Since contributors apparently do not appear in the references, they are now indicated as co-authors of the code. The reference has been modified accordingly.

- the large archive size of 234 MB is due to inclusion of "convenience copies" of external libraries and tools, which is neither expected nor described anywhere, and I'd consider it a malpractice as the libraries are straightforward to obtain. Examples:
    - 84.7 MB: MNH-V5-5-0/pub/ncl-6.4.0.tar.gz
    - 18.8 MB: MNH-V5-5-0/src/LIB/netcdf-c-4.7.4.tar.gz
    - 16.2 MB: MNH-V5-5-0/src/LIB/oasis3-mct_v3.tar.gz
    - 12.0 MB: MNH-V5-5-0/src/LIB/hdf5-1.12.0.tar.gz

- 11.0 MB: MNH-V5-5-0/src/LIB/eccodes-2.18.0-Source.tar.gz
- 8.6 MB: MNH-V5-5-0/src/LIB/RAD/ecrad-1.4.0.tar.gz
- 6.5 MB: MNH-V5-5-0/pub/ga-5-0-3.tar.gz

- Moreover, the MNH-V5-5-0/bin_tools folder contains 43 MB of binary files which are not portable (e.g. would work only on Linux systems with outdated libpng12.so.0 present), and also not expected to be included in a source archive.
- aiming to double check the correctness of the diffusivity formula (16) constant value given with non-SI unit in the paper, and expecting a single code location for the constant, I have spotted a troubling amount of code duplication:
    - src/src_isotopes/isotopes_tendencies.f90:528: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/src_isotopes/ice_adjust.f90:625: ZDV(:,:,:) = 0.211E-4 * (ZT(:,:,:)/XTT)**1.94 * (XP00 / ZPRES(:,:,:))
    - src/SURFEX/canopy_blowsnw_subl.F90:78: ZDV(:,JK) = 0.211E-4 * (PT(:,JK)/XTT)**1.94 * (XP00 / PP(:,JK))
    - src/MNH/lima_tendencies.f90:478: ZDV(:) = 0.211E-4 * (ZT(:)/XTT)**1.94 * (XP00 / PPABST(:))
    - src/MNH/ice4_tendencies.f90:430: ZDV(JL) = 0.211E-4 * (ZT(JL)/XTT)**1.94 * (XP00 / PPRES(JL))
    - src/MNH/lima_adjust.f90:530: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/lima_adjust.f90:823: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/lima_adjust.f90:935: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/lima_notadjust.f90:353: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/subl_blowsnow.f90:376: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/rain_ice_elec.f90:2455: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/ch_aqueous_tmicice.f90:1059: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/lima_cold_slow_processes.f90:324: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/lima_mixed.f90:440: ZDV(:) = 0.211E-4 * (ZZT(:)/XTT)**1.94 * (XP00 / ZPRES(:))
    - src/MNH/rain_ice_slow.f90:120: PDV(:) = 0.211E-4 * (PZT(:)/XTT)**1.94 * (XP00 / PPRES(:))

From software engineering standpoint, the repeated definition of constants across the codebase (15 times) and the lack of code reuse (i.e., copy-pasted lines instead of shared function definition) are both anti-patterns. This approach leads to bug-prone code, technical debt, high software maintenance costs, and hindered opportunities for future developments.

We are not responsible for the MNH-v5-5-0 content. This archive is built and delivered by the Meso-NH support. The philosophy is to provide code that can be used by an inexperienced user, which may explain the libraries that are included.

Version 5-5-0 is a relatively old version of Meso-NH (delivered in 2021), and important modifications in the code and its environment have been conducted recently. Concerning the bin_tools folder, it has been cleared out in the new version 6-0 of Meso-NH. As for the code duplication, an effort has been recently made to avoid such practices. When the stable water isotope scheme will be implemented in the most recent version of Meso-NH, we will take care of avoiding code duplication, and instead use shared functions. Your comment has been forwarded to the Meso-NH support team.

References:

- fix DOI in Caniaux et al. 1994 (should be 10.1175/1520-0469(1994)051<2046:ANSOTS>2.0.CO;2)
- fix DOI in Chang et al. 1993 (should be 10.1175/1520-0469(1993)050<0161:TDMSOS>2.0.CO;2)
- fix DOI in Chong et al. 1987 (should be 10.1175/1520-0493(1987)115<0670:ATSLOD>2.0.CO;2)
- fix DOI in Gamache & Houze 1981 (should be 10.1175/1520-0493(1982)110<0118:MAMAWA>2.0.CO;2)
- fix DOI in Hall & Pruppacher 1976 (should be 10.1175/1520-0469(1976)033<1995:TSOIPF>2.0.CO;2)
- fix DOI in Meyers et al. 1992 (should be 10.1175/1520-0450(1992)031<0708:NPINPI>2.0.CO;2)
- fix DOI in Redelsperger & Lafore 1988 (should be 10.1175/1520-0469(1988)045<1334:ATDSOA>2.0.CO;2)

All references have been corrected.

HTH

Thank you for all the comments that helped improve our manuscript.