We would like to acknowledge the reviewers for the time and effort in critically evaluating the manuscript. We have considered their suggestions and remarks, made answers to the reviewers' questions, and carefully modified the manuscript according to the revision comments.

Reviewer 1

The manuscript titled "Chemical characterization of cloud water at Monte Cimone (Italy): impact of air mass origin and assessment of atmospheric processes" presents a detailed description on the cloud water chemistry in Italy mountaintop by emphasizing the significant impact of air mass sources. In general, this study shows a very comprehensive analysis of inorganic and organic ions, dissolved organic carbon (DOC), H2O2, trace metals and microbial cells in the collected 26 cloud water samples. I very appreciate the field work and valuable data provided by the authors. Although the authors show nearly all matters about individual samples, I have some concerns regarding the logical structure, figures/tables organization, and reasonable explanations. Substantial revision is still necessary for a better readability. My comments, either major or minor, are listed below in the order of main text.

We thank the reviewer for the constructive comment and we worked on the text, especially section 3.1 to rearrange the discussion and the storyline.

1. The abstract summarized the three types of origins of cloud chemistry with major ions, but didn't mention the other important subsections studied, for example the oxidants, DOC, metals and microorganisms. That partial abstract will mislead my first view of this paper. Please revise the abstract with key findings of cloud components.

   We have revised the abstract following the reviewer's suggestions by adding more information about DOC and H_2O_2 in the description of the three periods in line 39-40.

   Lines 39-40: "Across the campaign, DOC ranged from 1.6 to 4.3 mgC L^{-1} while H_2O_2 reached its maximum during period 3 (71.8 ± 35.4 μmol L^{-1}), highlighting enhanced oxidant levels under polluted conditions."

2. Page 6, line 132, and Table S4, Figure 6: as the BOOGIE cloud impactor is made by aluminum (Vaitilingom et al., 2025), it may contain other metals besides Al. For example, the blank sample had a concentration of Cu, Mn, and Sb higher than that of cloud samples as shown in Table S4. Therefore, when the authors discuss the metals in cloud water in section 3.5, please make it clear that if the sample concentrations have deduced the blanks, and if the high blanks of some metals affect the conclusion. That is to say, could we believe the determined concentrations of specific metals with high blanks for cloud water sampler.

   Section 2.3 (line137) has been revised to provide additional clarification on the use of the blank. It was not subtracted from the cloud water samples because some samples exhibited concentrations lower than those measured in the blank. The relatively high concentrations of Cu, Mn, and Sb observed in the blank can be explained by the blank collection procedure. It was prepared in clear-sky conditions by spraying MilliQ water onto the clean cloud collector. During this process, atmospheric particles, with a concentration of 766.6 ± 24.0 #/cm^{-3}, may have dissolved into MilliQ water, thereby increasing the concentrations of certain trace metals. For this reason, we considered it more appropriate to focus on relative proportions rather than on absolute differences between the blank and the cloud water samples.

   Line 137-140: "The result in section 3.5 presents the comparison between blank and cloud water samples: as some samples had values below the blank, the blank was not subtracted. As the blank is prepared in clear sky conditions, atmospheric particles, with concentration of 766.6 ± 24.0 #/cm^3, may dissolve into MilliQ water, thereby increasing the concentrations of certain trace metals."

3. Section 2.4.1: Here the authors provided the measurements of trace gases. I am also interested in SO2, the important precursor of sulfate, for comprehensive understanding. Is that possible to add the information of SO2?

SO_2 concentrations are measured continuously at the observatory and data are available at GAW website. However, as shown in Figure 1 below, SO_2 levels remained very low throughout the sampling period and most of the time below the nominal detection limit of 0.11 ppb. Given these low concentrations, SO_2 is unlikely to have a significant impact on the concentration measured of SO_4^{2-} in the cloud water samples.

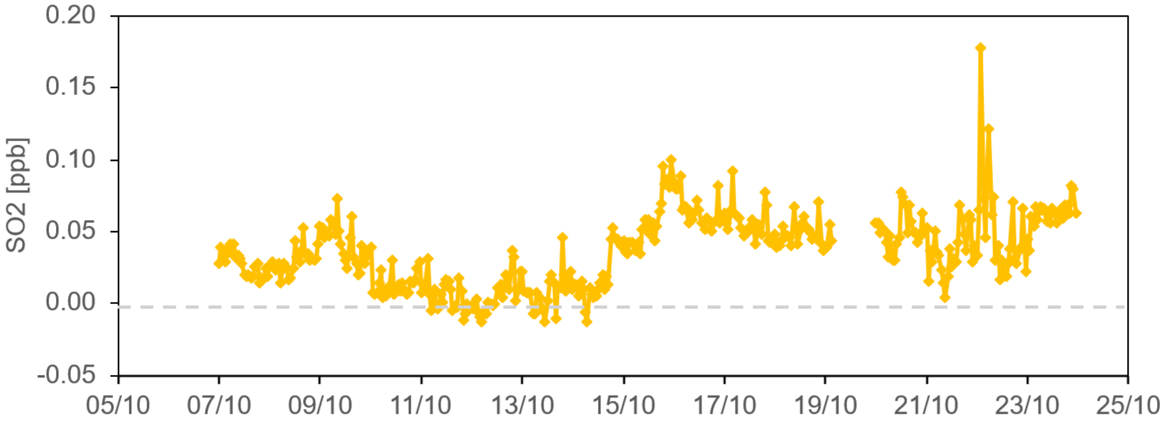

Figure 1: Temporal evolution of SO_2 during the campaign.

4. Section 3.1 is an important part of the paper, but it is too detailed and sometimes verbose for me to follow. I am afraid that most of the discussed figures are in the supporting information, rather than Figure 1 in the main text, which is the most inconvenient thing to be improved. I suggest to add a time-series figure of the full set of major chemical compositions (like Fig. S5 and Table S2) to the main text. The pies in Figure 1 should have different size indicating their relative concentrations. Also, why does Figure 1 only show 6 out of 8 measured ions and exclude DOC?

We appreciate the reviewer's comments regarding Section 3.1. The section was rearranged substantially to improve the readability and narrow its focus. Following the reviewer's suggestion, we have moved Fig. S5 to the main text, as suggested, it is now Figure 2. We chose not to modify the size of the pie charts in Figure 1, as scaling them proportionally would have made it difficult to read. The reviewer pointed out that only six out of the eight measured ions are presented in Figure 1 and we excluded DOC. The contributions of Mg^{2+} and K^+ were negligible during all three periods (consistently below 3%), as shown in Table 1 of this document. For this reason they were not included in the pie plots. Nevertheless, as suggested, we have included DOC relative concentration as a text in the three periods in Figure 1 of the manuscript, as reported below.

Period	**Cl^-**	**NO_3^-**	**SO_4^{2-}**	**Na^+**	**NH_4^+**	**Ca^{2+}**	**Mg^{2+}**	**K^+**
1	34.0 %	9.0 %	4.3 %	30.7 %	11.9 %	4.7 %	*2.1 %*	*3.3 %*

2	7.2 %	14.9 %	11.2 %	7.9 %	22.6 %	32.1 %	*1.7 %*	*2.4 %*
3	25.0 %	16.4 %	11.6 %	22.1 %	13.5 %	8.4 %	*1.5 %*	*1.6 %*

Table 1: Percentage contribution of the analyzed ions in the cloud water samples for each period.

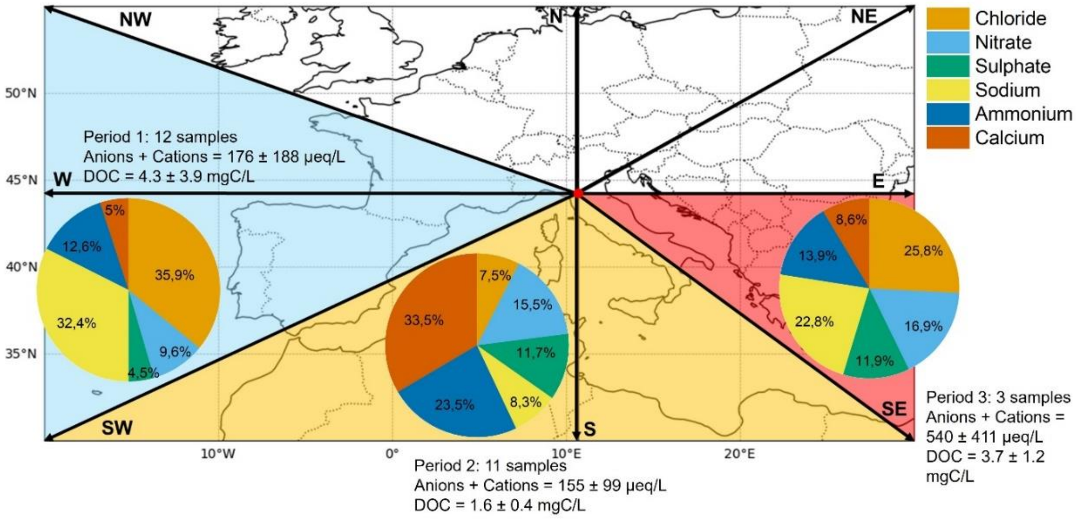

Figure 1 of the manuscript

5. Why the main text did not explain Figure 2 or should Figure 2 be replaced by other type of figures?

   As Figure 2 was only used to support specific points discussed in Section 3.1, it has been moved to the Supplementary Material, where it is now presented as Figure S5.

6. Line 286: all ions concentrations of Period 2 are low, for which part? Cloud water, or PM1? Please show the concentrations of Ca2+ in Figure S5 for clarifying the dust effect on cloud and PM.

   The full section was reorganized to better clarify the impact of dust on the chemical composition of cloud water, especially Ca^{2+}. Below, the reviewer may find a figure combining dust events and calcium concentration in cloud water. As highlighted in the correlation plot (Figure S7), Ca^{2+} concentrations increase during dust events. Nonetheless, high Ca^{2+} concentrations are also observed in the last period, especially on 22/10. This sample was not identified as a dust event based on aerosol measurements, which showed similar coarse and fine mass concentrations. This may indicate mixed sources during the entire Period3. The present figure was not included in either the main manuscript or in supplementary to avoid overloading the manuscripts with figures.

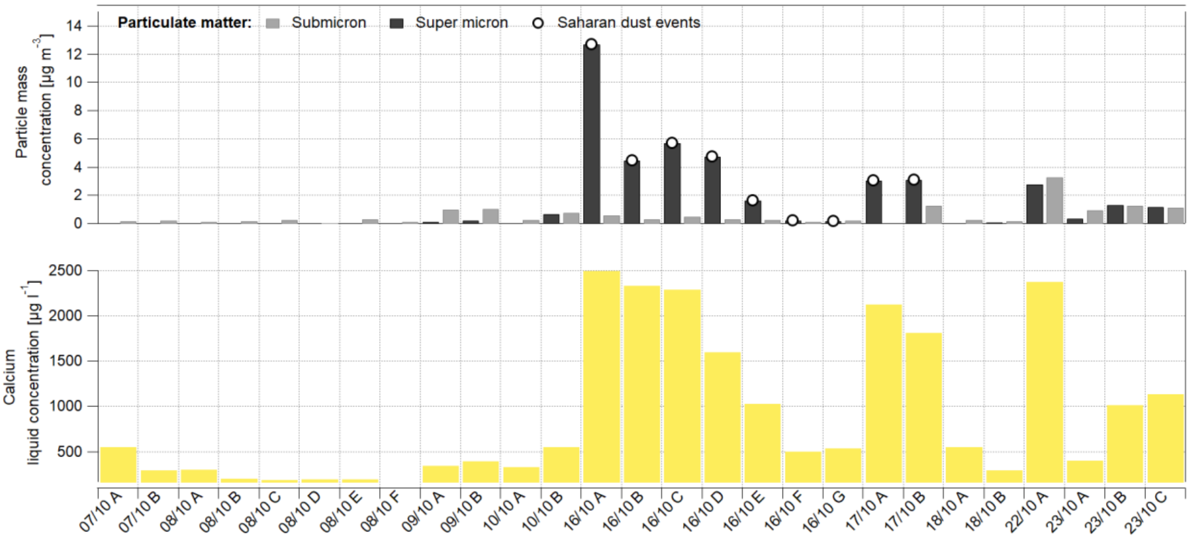

Figure 2 Temporal evolution of particle mass concentration and calcium liquid water concentration.

7. Line 348: “Nevertheless, the absence of Cl^-_{PM} and the depletion of $NO_3^-{}_{PM}$ in particles, compared to cloud water, attest the marine input, similarly to samples of Period 1.” Why SO_4^{2-} in particles are due to pollution but NO_3^- is depleted? And is it possible that the Cl-depletion in particles can be further discussed for atmospheric conversion?

   A more detailed analysis on the $NO_3^-{}_{PM}$ indicates a slight increase in Period 3 (average period 3) compared to the rest of the campaign (average period 1 and 2), so $NO_3^-{}_{PM}$ is not depleted.

   The statement at line 343-347 was modified as: “The low NO/NO2 ratio (Figure S6) and $NO_3^-{}_{PM}$ average concentrations (0.08 ± 0.01 µg/m^3, the highest of the campaign) would suggest the occurrence of relatively aged anthropogenic emissions.”

   Regarding Cl^-, it does not vary significantly across the whole campaign, including period 3. Hence, we could not provide more insight on Cl^- conversions or other cloud-aerosol related processes. Hence, the statement at line 348 was removed.

   Regarding $SO_4^{2-}{}_{PM}$, when the degree of neutralization, defined as the equivalent ratio of ammonium to the sum of sulphate, nitrate and chloride in PM is very low (0.55) and the amount of SO_4 is the highest, it explains that the pH reaches its lowest value and therefore the anthropogenic influence of the trajectory of 22/10.

   The sentence at line 352-353 was modified as: “However, it decreases to 4.1 on 22/10, coinciding with peak $SO_4^{2-}{}_{PM}$ and a low neutralization degree, which confirms that this sample is under continental influence with anthropogenic input.”

8. Line 395: “The concentration of Fe2+/Fe3+ is below…”, please reword this statement to avoid misleading of the measurement of total dissolved Fe rather than speciated Fe ions in this study.

   As suggested by the reviewer, this statement has been reworded.

   Line 393: “The concentration of total iron is below 0.3 µmol L^{-1}”

9. Lines 408-414: I did not find SO2 concentration in Figure S1. The high concentrations of H2O2 were attributed to direct industrial emission. Can you estimate how long time

will the released H2O2 exist in the atmosphere and transport to the observation site at which concentration level?

SO2 concentrations are not reported in Figure S1, because they are always below 4.7 ppb and thus not significant for H_2O_2 depletion.

The concentration of 104 µM in sample 22/10 is potentially due to the release of hydrogen peroxide from the industrial plant of Rosignano Solvay, the biggest producer of peroxides and hydrogen peroxide in Europe. The plant is also a major producer of sodium carbonate and bicarbonate, but no sulfur-containing products are produced at this site.

It is extremely difficult to estimate the concentration at the source point without using a 3D atmospheric model, which is beyond the scope of this work. We tentatively estimate the losses due to H_2O_2 photolysis using the distance between the two locations as the crow flies (96.75 km) and the differential equation

$$\frac{d[H_2O_2]}{dt} = -J[H_2O_2]$$

Where J is the photolysis rate in s^{-1}. This one was estimated from the simulations presented in Pailler et al. (2023) for a location with similar actinic flux (same latitude) between 10 AM and 4 PM. If we considered an average wind speed of 6 m/s, the time needed to cover this distance is ≈ 4.5 h. Since the sampling started at 4.30 PM (local time) we can assume that the corresponding emission was around noon. The numerical resolution of the differential equation gives a concentration of H_2O_2 at the source point of 113 µM. Nevertheless, this calculation is based only on H_2O_2 photolysis, without considering dilution through air mass mixing. Moreover, we considered only “in cloud” photolysis, but cloud could have appeared hours after the emission.

Given these limitations, this estimate should be interpreted with caution, and no modification have been made to the article.

10. Line 426: “Figure 4a reports in yellow the concentration in daytime samples and in blue in night-time. The concentrations in night-time samples are generally higher than in day-time samples, except for sample 16/10 G, collected at sunset.” The sentences are redundant to the caption of Figure 4.

As suggested by the reviewer, to avoid repetitions between line 417 and Figure 4, the caption was revised.

Lines 994-999:” Figure 4: a) Boxplot of hydrogen peroxide concentration in cloud water. b) Correlation between nitrate concentration (left y-axis, black dots) or sulphate concentration (right y-axis, red circles) and hydrogen peroxide in cloud water. The linear correlation is reported in grey for nitrate and in red for sulphate, with 95% confidence intervals. Equations and coefficient of determinations are reported in the inset tables”

11. Please revise the caption of Figure 3 to be more concise.

The caption of Figure 3 has been revised to be more concise.

Lines 987-991:” Figure 3: Biplot of the principal component analysis (PCA) performed on cloud samples collected at CMN. Loadings represent the ions, scores represent the samples. Colored areas depict the different classes of samples: plain, Saharan, polluted/continental, highly marine, and, highly marine or polluted. The blank sample is reported in red. The red arrow highlights the depletion of Ca^{2+} during the cloud event 16/10."

12. What does the error bar mean in Figure 4a for individual sample? Set the same y-axis scale for nitrate and sulfate concentrations in Figure 4b using only left y-axis.

    The error bar in Figure 4a for individual sample represents the analytical error between 3 measurements on each sample. As suggested, the same y-axis scale for nitrates and sulphate concentrations was modified according to the reviewer's comment.

13. Line 430 suggests the positive correlations between H2O2 and nitrate or sulfate. It is contrast to line 414 stating low SO2 concentration to explain high H2O2. Can we imagine that H2O2 had similar anthropogenic sources with other pollutants?

    We agree with the reviewer that SO_2 and H_2O_2 could have similar sources and we checked the potential emissions of SO_2 in the region of interest. As explained in point 9, the industrial plant in Rosignano Solvay is also leader in the production of sodium carbonate and bicarbonate, but no sulfur-containing products are produced at this location.

    The emission and formation pathways of H_2O_2 is highly uncertain, especially due to multiphase chemistry, as recently summarized by Duan et al., (2025). Considering the conditions at the Cimone stations, characterized by frequent cloud formation, variable atmospheric circulation and strong diurnal variability of the atmospheric boundary layer thickness, it is impossible to address univocally H_2O_2 emissions/formation with gas (NO_x and SO_2) and aerosol particles (black carbon, sulfate and nitrate) typically emitted by anthropogenic sources. Said that, a potential direct source could be leakage from the hydrogen peroxide production plant in Rosignano Solvay as discussed in the answer to Comment 9.

14. Figure 5: As it shows much less information and is discussed in 3 sentences in the main text, I suggest move it to SI.

    We understand the reviewer's concerns regarding Figure 5. While it is true that the figure is briefly discussed in the main text, we consider it important to retain it because our ongoing research focuses on the characterization of dissolved organic matter in cloud water (Pailler et al. 2024, Bianco et al. 2018). This figure serves to introduce our future work.

15. Section 3.6: there are too much short paragraphs, which can be shortened into about four paragraphs.
    We agree with the reviewer that the reading is difficult with this separation and Section 3.6 has been modified into 3 paragraphs.

    Lines 509-555:" Living microorganisms are ubiquitous in the atmosphere. Most of them originate from vegetation, soil and sea and can travel long distances (Griffin et al., 2001). It is thus particularly important to better understand their impact on cloud water, as they may modify cloud composition and reactivity (Delort et al., 2017). As reported in the Section 2.7, cloud samples dedicated to microbiological analysis are collected in sterile conditions. The two collectors deployed are operated almost at the same time. Nevertheless, some time differences are unavoidable, mainly due to the mounting and dismounting of the collectors. The precise sampling times are reported in Table S1. Tables S5 and S6 details the concentrations of culturable bacteria-like CFUs and mycelial fungi, and total cells for each cloud sample in which a microbiological analyses are carried out.

Cell concentrations are highest during october 16th and 17th sampling events (samples A and B), ranging from $2.4 \pm 0.5 \times 10^5$ to $1.0 \pm 0.3 \times 10^6$ cells·mL^{-1}. This peak is likely explained by a Saharan dust event occurring on those dates, which transports large quantities of particles and likely increase the number of particle-attached microorganisms. Interestingly, culturable cell concentration do not follow this trend, with only 470 culturable cells·mL^{-1} (including both mycelium and colony-forming units), a value very close to the median culturable concentration for the entire campaign (median = 470 cells·mL^{-1}; range = 400–563 cells·mL^{-1}). This sample is also one of only two in which bacteria-like CFUs outnumber mycelium-forming units, the other being collected on 07/10. However, this pattern does not appear to be related to air mass origin, as the two samples are under Saharan and marine influence, respectively. Samples influenced by marine air masses contained 8.0×10^3 to 4.1×10^4 cells·mL^{-1}, approximately one order of magnitude lower than in Saharan-influenced clouds. These concentration differences are associated with the altitude of air mass transport over the Mediterranean Sea. In comparison, polluted clouds contain between 3.1×10^4 and 1.4×10^5 cells·mL^{-1}.These values are within the range of concentrations typically observed in cloud water at puy de Dôme 1465 m, Central France, a site exposed to air masses from oceanic and continental influences), between ~3× 103 to ~3× 105 cells/mL. Typically, it is reported that the abundance of airborne microbes increases with increasing influence of terrestrial sources (Mayol et al., 2017), and is higher in urban than continental and coastal contexts (Shaffer & Lighthart, 1997). Values as low as < 103 bacteria cells/m3 of air are reported near the surface over oceans (Mayol et al., 2017; Rossi et al., 2025). Consecutive sampling on 17/10 (2-hour interval, same cloud event) reveals marked differences in culturable microbial concentrations (20 vs 63 bacteria-like CFUs·mL^{-1}, and 427 vs 163 mycelium-forming units for samples A and B, respectively), despite no significant variation in total cell concentrations (2.4×10^5 vs 2.9 × 106 cells·mL^{-1}). This illustrates the dynamic nature of clouds, even on short timescales: while total microbial abundance may remain relatively stable, community viability and culturability can fluctuate rapidly, likely due to environmental change or microphysical processes within the cloud. Consistently with our observations, it is typically observed that much fewer than 1% of the total bacteria in clouds can be recovered by culture under classical conditions, while fungi often maintain higher cultivability rate (e.g.,Vaitilingom et al., 2012) The ability of microbial cells to form colonies (i.e. grow on a culture medium) can be affected by many parameters, including viability, culture conditions, and others less understood mechanisms leading to a viable-but-non-culturable (VBNC) state (Pinto et al., 2015), which is often recognized in bacteria as a stragegy to tolerate stressful conditions (Dong et al., 2020).

Overall, cell concentrations measured at Monte Cimone are consistent with those reported at other cloud sampling sites (~10^3 to 10^5 cells·mL^{-1}) (Amato et al., 2005; Bauer et al., 2002; Sattler et al., 2001). On average, cultivable cells represent only 0.5–6% of the total community, a proportion commonly observed in atmospheric samples (Amato et al., 2007). Although they represent a small fraction of the total microorganisms present in samples, cultivable organisms remain essential for downstream applications such as laboratory experiments (e.g. Vaïtilingom et al., 2013) or cloud simulation chamber studies (e.g. Amato et al., 2015).”

16. Line 540: it seems that air masses originating from continental areas contain one order of magnitude more microbial cells. Besides the altitude, can you find data or literatures comparing the abundant of atmospheric microbials in land and marine areas to support your findings?

    We thank the reviewer for this relevant comment. We indeed indicate that marine air masses carried « 8.0 × 10^3 to 4.1 × 10^4 cells·mL^{-1}, approximately one order of magnitude lower than in Saharan-influenced clouds”, and « In comparison, polluted clouds contain between 3.1 × 10^4 and 1.4 × 10^5 cells·mL^{-1} ».

    These values are within the range of concentrations typically observed in cloud water at puy de Dôme 1465 m, Central France, a site exposed to air masses from oceanic and continental influences), between ~3× 10^3 to ~3× 10^5 cells/mL. In general, the abundance of airborne microbes increases with the influence of terrestrial sources (Mayol et al., 2017), and is higher in urban compared to continental and coastal environments (Shaffer and Lighthart, 1997). Values as low as < 103 bacteria cells/m^3 of air are reported near the surface over oceans (Mayol et al., 2017; Rossi et al., 2025).

    This information has been added to the text (as, lines 530-536: “These values are within the range of concentrations typically observed in cloud water at puy de Dôme 1465 m, Central France, a site exposed to air masses from oceanic and continental influences), between ~3× 10^3 to ~3× 10^5 cells/mL. Typically, it is reported that the abundance of airborne microbes increases with increasing influence of terrestrial sources (Mayol et al., 2017), and is higher in urban than continental and coastal contexts (Shaffer and Lighthart, 1997). Values as low as < 10^3 bacteria cells/m^3 of air are reported near the surface over oceans (Mayol et al., 2017; Rossi et al., 2025).” and the corresponding references were included.

17. Lines 546-549: can you further explain the primary factors influencing culturable microbials?

    Thank you for raising this point. We propose to insert in the lines 542-548 the paragraph:

    « Consistently with our observations, it is typically observed that much fewer than 1% of the total bacteria in clouds can be recovered by culture under classical conditions, while fungi often maintain higher cultivability rate (e.g., Vaïtilingom et al., 2012). The ability of microbial cells to form colonies (i.e. grow on a culture medium) can be affected by many parameters, including viability, culture conditions, and others less understood mechanisms leading to a viable-but-non-culturable (VBNC) state (Pinto et al., 2015), which is often recognized in bacteria as a strategy to tolerate stressful conditions (Dong et al., 2020). »

We would like to acknowledge the reviewers for the time and effort in critically evaluating the manuscript. We have considered most of their suggestions and remarks, made supplementary answers to the reviewers' questions, and carefully modified the manuscript according to the revision comments.

Reviewer 2:

This manuscript titled "Chemical characterization of cloud water at Monte Cimone (Italy): impact of air mass origin and assessment of atmospheric processes" examines the physico-chemical composition of cloud water at Monte Cimone, focusing on the role of air mass origin. The study presents valuable dataset covering a wide range of chemical components (e.g. major organic and inorganic ions, black carbon and dissolved organic carbon (DOC), trace gases, trace elements, and biological components) from 26 samples. The field work and the effort put into collecting and analyzing these samples are highly appreciated.

Overall, the manuscript provides useful and interesting results. However, some improvements in the abstract and the organization and clarity of explanations in the main paper would help make the paper easier to follow. My specific comments are listed below.

Specific comments:

1. The abstract mainly focuses on the three mass origins and major ions, but it did not mention other important components studied, such as oxidants, DOC, metals, and microbiological components. Since these are also key parts of the paper, it would be helpful to briefly include their main findings in the abstract to better reflect the full scope of the study.

   We thank the reviewer for this suggestion. As reviewer 1 raised a similar comment, we have revised the abstract accordingly by adding further information on DOC and H_2O_2.

   Lines 39-41: "Across the campaign, DOC ranged from 1.6 to 4.3 mgC L^{-1}, while H_2O_2 reached its maximum during period 3 (71.8 ± 35.4 µmol L^{-1}), highlighting enhanced oxidant levels under polluted conditions."

2. In the abstract and conclusion, you mentioned that 26 cloud water samples were analyzed. But when I counted the cloud water samples in some figures (for example, in Fig. S3 upper panel, Fig. S5), I counted 27 samples. Could you clarify which one is accurate?

   We agree with the reviewer's remark regarding the figure legend. We have corrected the label "23/10 A" to "23/10 Rain," as this sample corresponds to a rain event and not to a cloud water sample. Consequently, the study includes a total of 26 cloud water samples.

3. Line 256: "The composition is well balanced between inorganic ions (Cl^-, NH_4^+, NO_3^-, and SO_4^{2-})". Could you clarify what is meant by well balanced? Does this refer to having similar concentrations? And also, is this for aerosol phase or aqueous phase? I am assuming aerosol phase, but please clarify and use the appropriate notation ($_{PM}$ or $_{CW}$).

   We agree with the reviewer that some formulations were not clear, and we rephrased the sentences accordingly. We used the term well balanced to indicate that the concentrations of inorganics species in the aqueous phase and aerosol phase are proportional. Notations have been corrected as suggested.

   Line 257-260:" The marine influence is also confirmed by the sea-salt sulphate [ss SO_4^{2-}] fraction, which averaged around 40% and reached up to 70% in individual samples during Period 1. This is remarkably higher than in the other periods, where the average contribution remained below 10%, as shown in Figure S3"

4. Line 257: Did you calculate Cl depletion? It would be nice to quantify Cl depletion for each sample. You may refer to Edwards et al. (2024) for guidance on the calculations.

We thank the reviewer for this interesting comment. Based on the article by Edward et al 2024, we were able to calculate Cl^- depletion and find a value of 34.3 ± 20.3%. We used the following equations:

$$\%Cl^-_{Depletion} = 100\frac{ssNa^+\left(\frac{Cl^-}{Na^+}\right)_{ss} - Cl^-_{bulk}}{ssNa^+\left(\frac{Cl^-}{Na^+}\right)_{ss}}$$

with $ssNa^+$ calculated with the following equation :

$$ssNa^+ = \frac{Ca^{2+}_{bulk} - Na^+_{bulk}(\frac{Ca^{2+}}{Na^+})_{dust}}{(\frac{Ca^{2+}}{Na^+})_{SS} - (\frac{Ca^{2+}}{Na^+})_{dust}}$$

With :

- Cl^-_{bulk}, Ca^{2+}_{bulk}, and Na^+_{bulk} are the concentration of Cl^-, Ca^{2+} and Na^+ measured in the cloud water samples respectively.
- $\left(\frac{Cl^-}{Na^+}\right)_{ss} = 1.81$
- $(\frac{Ca^{2+}}{Na^+})_{dust} = 1.78$
- $(\frac{Ca^{2+}}{Na^+})_{SS} = 0.038$

The value found for Cl^- depletion are reported in Table 2:

	Chloride µmol L^{-1}	Sodium µmol L^{-1}	Calcium µmol L^{-1}	$ssNa^+$ µmol L^{-1}	% depletion Cl^-
071024 A CMN	15.2	30.2	13.9	22.9	*63.2*
071024 B CMN	3.8	12.5	7.4	8.5	*75.6*
081024 A CMN	11.9	11.2	7.6	7.1	*7.0*
081024 B CMN	8.6	6.9	5.1	4.1	*0.0*
081024 C CMN	6.7	11.1	4.8	8.5	*56.6*
081024 D CMN	26.5	21.5	4.9	19.2	*23.5*
081024 E CMN	25.9	23.1	5.0	20.8	*31.1*
081024 F CMN	37.0	31.5	4.1	29.9	*31.5*
091024 A CMN	84.8	70.4	8.7	66.9	*30.0*
091024 B CMN	107.0	99.1	10.0	95.5	*38.1*
101024 A CMN	55.8	43.0	8.3	39.1	*21.2*
101024 B CMN	289.2	246.9	13.9	244.3	*34.6*

161024 A CMN	8.3	11.6	62.3	0.0	*0.0*
161024 B CMN	2.9	6.5	58.3	0.0	*0.0*
161024 C CMN	3.4	6.1	57.2	0.0	*0.0*
161024 D CMN	1.0	2.9	40.0	0.0	*0.0*
161024 E CMN	3.6	2.6	25.7	0.0	*0.0*
161024 F CMN	<DL	1.0	12.7	0.0	*0.0*
161024 G CMN	<DL	3.0	13.5	0.0	*0.0*
171024 A CMN	24.2	26.4	53.0	0.0	*0.0*
171024 B CMN	26.1	28.9	45.2	3.6	*0.0*
181024 A CMN	0.9	4.9	13.9	0.0	*0.0*
181024 B CMN	1.2	2.1	7.4	0.0	*0.0*
221024 CMN	254.7	224.7	59.2	195.7	*28.1*
231024 Rain CMN	19.4	15.8	10.1	10.4	*0.0*
231024 B CMN	48.1	41.8	25.4	28.2	*5.7*
231024 C CMN	46.8	42.8	28.4	27.4	*0.0*

Table 2: Chemical Characterization of Cloud Samples (Major Ions, ssNa$^+$ and Cl$^-$ Depletion).

5. Line 261: “Cl$^-$ and NO$_3^-$”. Please clarify whether this refers to the aerosol or aqueous phase.

   As requested by the reviewer, we have clarified the sentence.

6. Line 302: I am curious how the chemical species correlate to each other. Did you perform a simple correlation analysis between all the measured components (other than correlation shown in Fig. 4b, Fig. S3, and Fig. S7)?

   We thank the reviewer for this very relevant question. We performed the same PCA as presented in Figure 3, this time including the ion concentrations from the aerosol phase. Magnesium, sodium, and calcium were excluded from the analysis because their concentrations were only available for the aqueous phase. The results, shown in Figure 2 of this document, show a strong correlation between the aerosol and aqueous phases for sulphate and ammonium. In contrast, nitrate and chloride do not exhibit a similar correlation. This discrepancy can be explained by the fact that Cl$^-$ and NO$_3^-$ measured in the cloud water are present as inorganic ions (NaCl and NaNO$_3$), which are not detected by ACSM (as shown line 268 from section (3.1)).

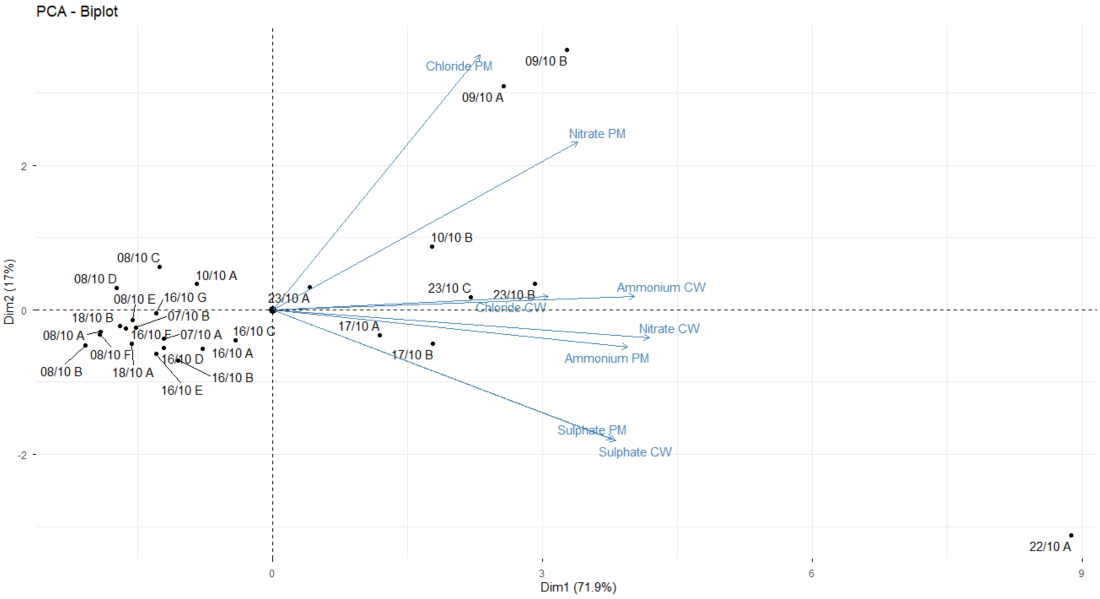

Figure 2: Biplot of the principal component analysis (PCA). Loadings represent ions from the aqueous phase and aerosols phase. Scores represent the samples.

7. Lines 439-441. You mentioned that "LWC is not measured during the campaign", but then you proceeded with "the LWC for the last samples". Please clarify this point.

   The reviewer is right. We encountered an issue with the LWC measurements, as the instrument (PVM), kindly lent by TROPOS colleagues D. Van Pinxteren, S. Mertes and U. Käfer, did not arrive to Monte Cimone until 23/10. Consequently, no LWC measurements were not available prior to the last day of the campaign.

8. Line 980: For Figure 6a, did you correct the sample concentration for the blank concentration? The concentrations of Mn and Cu are a bit high, and some samples were even lower than the blank concentration.

   As requested by Reviewer 1, we have provided additional information on the use of the blank. Section 2.3 (line137) has been revised to provide additional clarification on the use of the blank. It was not subtracted from the cloud water samples because some samples exhibited concentrations lower than those measured in the blank. The relatively high concentrations of Cu, Mn, and Sb observed in the blank can be explained by the blank collection. It was prepared in clear-sky conditions by spraying MilliQ water on the clean cloud collector. During this process, atmospheric particles, with concentration of 766.6 ± 24.0 #/cm^3, may dissolve into MilliQ water, thereby increasing the concentrations of certain trace metals. For this reason, we considered it more appropriate to focus on relative proportions rather than on absolute differences between the blank and the cloud water samples.

Technical comments:

Line 126: should be 'TOC-VCPH/CPN analyzer' instead of "TOCVCPH/CPN TOC analyzer"

The sentence has been modified.

Lines 248-252: The sentence is a bit confusing, consider revising.

The sentence has been modified.

Line 253: should be 'PM_{TOT}' instead of "total PM_{TOT}"

The spelling has been modified.

Lines 273-279: These lines can be shortened into two sentences to improve flow.

We thank the reviewer for this suggestion. The lines have been revised and shortened into two sentences to improve the flow of the text.

Line 422: "..reported by (Laj et al., 2001) and (Vione et al., 2003)" should be 'reported by Laj et al. (2001) and Vione et al. (2003)'. Please check similar issues throughout the paper since I've seen a few like this.

We have taken the reviewer's comment into account and corrected these issues.

Lines 426-428. Be consistent with the use of "daytime and nighttime" versus "day-time and night-time".

The manuscript has been corrected to use "day-time" and "night-time" consistently.

Line 504: should be 'hypothesis' instead of "hypothesys".

It has been corrected.

Line 969. It's hard to read the coefficient of determination in Figure 4b. Consider minimizing the significant figures to 2-3 and improve the quality of the figure. Nitrate and sulfate can also share the same y-axis since the range of values is similar.

The plot has been modified according to the reviewer's suggestions.

Line 974. For Figure 5 x-axis label, please be consistent with the samples naming convention. Use dd/mm instead of ddmmyy.

Figure 5 has been revised in accordance with the reviewer's comment.

Line 981. I don't think Figure 6c is mentioned in the main manuscript.

The reviewer is right, Figure 6c is now mentioned in the main manuscript (line 491), as well as Figure 6a (line 483) and Figure 6b (line 476).

Figure S3 (lower panel). Y-axis label should be 'Chloride' instead of "Cloride"

The plot has been modified according to the reviewer's suggestions.

In Tables S1-S3, you used the sample ID 23/10 Rain. Does this sample refer to 23/10A in Fig.S3 upper panel and Fig.S5? Please clarify.

We thank the reviewer for pointing this out. Sample 23/10 A has been renamed 23/10 Rain to maintain consistency across all figures.