1. INTRODUCTION

The dispersion profiles from the Meteosat Second Generation (MSG) satellite have been used in different studies aimed at deducing the microphysical characteristics of cloud masses (Prieto, 2006). It is also possible to make a dynamic interpretation of the variations that arise in the different profiles that are obtained. In fact, through the microphysical characteristics it is possible to identify the presence of ascents or descents within the cloud, the presence of wind or the appearance of hydrometeor accumulation zones at high levels. For example, ascending currents cause condensation, which can be detected from a microphysical perspective.

During snowfall episodes, the vertical dispersion profiles vary. The aim of this study is to explain the temporal variations seen in the dispersion profiles during snowfall episodes, with the help of the atmospheric data obtained by a radiometer installed in the reference point.

2. STUDY AREA AND DATABASE

The experimental campaign for gathering data was carried out between 17 November 2008 and 17 March 2009, over the winter period in Navalmedio (Madrid). Measurements were taken of aerosols (using an aerosol probe), ice nucleus (using a cloud chamber) and the wind components (using a SODAR). The vertical atmospheric profiles of the temperature and LWC (Liquid Water Content) were also obtained (using a radiometer), as well as the environmental conditions on the surface (weather station) and precipitating particles (using a disdrometer).

The radiometer provides us with information on the vertical temperature profiles and the Liquid Water Content (LWC) at 5-second intervals.

Throughout the study, 23 different precipitation episodes were analysed as an example that allowed us to identify in detail the presence of standard patterns profiles from a dynamic perspective in snowfall episodes. In this case, a systematic analysis was carried out of different MSG dispersion profiles using the Nubes software (PRAPRO, 2009).

For each of the episodes, MSG dispersion profiles were calculated which were systematically compared with data provided both by the radiometer (Liquid Water Content, LWC and temperature), and the disdrometer (distribution of hydrometeor sizes), in order to contrast the presence and type of precipitation.

3. CASE STUDIES

Different precipitation episodes were analysed as an example that allowed us to identify the presence of standard patterns or profiles from a dynamic perspective. Also, a number of especially relevant time intervals were selected for each of the episodes that were analysed, which were characterised either by high liquid water contents or by high precipitation rates (liquid or solid), which have been analysed in depth.
The complete temporal evolution of the following parameters was available for each of the episodes analysed:

- Synoptic situation at surface level and at 500hPa.
- Temporal evolution of the vertical temperature profile.
- Temporal evolution of the vertical relative humidity profile.
- Temporal evolution of the Liquid Water Content (LWC) during the episode.
- Temporal evolution of the precipitation recorded by the disdrometer.
- Dispersion profiles from the Meteosat Second Generation (MSG) satellite.

4. DYNAMIC PATTERNS OBTAINED FROM THE PRECIPITATING PROFILES

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Throughout the day, discontinuous precipitation was recorded in the form of snow in the Sierra de Madrid. The time interval analysed was from 10:00h until 12:30h.

Figure 2: Precipitation vs. LWP.

Figure 2 shows the evolution of the integrated liquid water content together with the number of precipitating particles provided by the data from the weather station, which provided us with information on the intervals with precipitation.

Profile A: Characterised by a very high LWC (1mm) without precipitation. In the profile from 11:00h we see that the higher we go, the albedo values increase due to the appearance of
small liquid droplets. The profile reveals the presence of rising currents. The absence of ice nucleus means that the LWC is high as no crystals have appeared.

Profile B: Characterised by high LWC, with weak precipitation in the form of snow. The dispersion profile (11:30h) becomes more vertical due to the fact that the ascending currents have diminished and the situation is predominated by precipitation in its early stages.

Profile C: Characterised by a low liquid water content with precipitation (12:30h). In the evolution from profile B, we may see how ice crystals have appeared at high levels (260K). This means that the crystals begin to grow at the expense of the liquid droplets, meaning that the LWP has decreased.

In summary, the drastic reduction of these values from 12.15h onwards is connected with the formation of ice crystals that grow and eliminate small droplets from the atmosphere. Their appearance also changes the vertical profile facilitating precipitation.

In the evolution from profile B, we may see how ice crystals have appeared at high levels (260K). This means that the crystals begin to grow at the expense of the liquid droplets, meaning that the LWP has decreased.

Figure 3: Vertical dispersion profiles at 11:00h (top left), 11:30h (top right), and 12:30h.

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This episode corresponds to the evolution of the previous episode. The vertical profiles of the temperature, humidity and LWC, as well as their evolution, can be seen in Figure 3, which also shows the evolution of the precipitation.

In this episode we focused our attention on the time interval between 11:13h and 12:20h, in which we would highlight two profiles.

Profile A: 11:13h. Characterised by a low liquid water content without precipitation. The profile shows how the ascending currents are especially high at low levels (up to the condensation level) and medium levels (from 250K upwards), producing an accumulation of liquid water in the condensation level, and another accumulation of crystals at high level.

Profile B: 12:00h. Characterised by a high liquid water content with precipitation. The profile becomes more vertical and sloped to the left with respect to profile A. In the profile from 12.00 we already see how a large part of the cloud mass is now around the isozero. An accumulation
zone of liquid water clearly appears, due to the increases and condensation, but also as a result of the fusion of the crystals in the upper layers.

In summary, we see how in the first profiles the liquid water content was reduced mainly due to the fact that the presence of ascending currents in the middle parts and the high number of freezing nuclei that were activated meant that the majority of the water was in the form of ice crystals at high altitude. Finally, the appearance of crystals in medium levels (probably due to descending currents) meant that a large amount of liquid water accumulated in the fusion layer.

Figure 4: Vertical dispersion profiles at 11:30h (left), and 12:00h (right).

5. CONCLUSIONS

1. The appearance of profiles sloping to the right (from ground level to the isozero) indicates the presence of ascending currents that facilitate condensation.

2. The profiles close to the surface, characterised by a high dispersion rate, reveal the presence of precipitation and the absence of ascending currents.

3. The profiles with a high LWC (Liquid Water Content) have dispersion diagrams that slope to the right, with concentrations of small or medium particles close to the condensation level; on the contrary, the profiles with low LWC have a high concentration of large-sized crystals close to the tropopause.

4. The abrupt reduction of the liquid water content within the cloud masses is characterised by profiles in which ice crystals appear in the growth phase.

5. The increase in the liquid water content inside the cloud is due to descending currents in the top of the cloud until the isozero, or otherwise ascending currents from the base to the condensation

6. REFERENCES


7. ACKNOWLEDGMENTS

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