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Seasonal variation of birch and grass pollen loads and allergen release at two sites in the German Alps

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HIGHLIGHTS

- Pollen/allergen concentrations were comparably low at a high altitude station.
- However, we also identified some days with relevant pollen/allergen concentrations.
- Some days with sampled pollen were related to no allergen content and *vice versa.*
- A risk assessment solely based on pollen concentrations is not inclusive.
- More attention should be paid to the actual allergen content of pollen.

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ABSTRACT

Less vegetated mountainous areas may provide better conditions for allergy sufferers. However, atmospheric transport can result in medically relevant pollen loads in such regions. The majority of investigations has focused on the pollen load, expressed as daily averages of pollen per cubic meter of air (pollen grains/m^3); however, the severity of allergic symptoms is also determined by the actual allergen content of this pollen, its pollen potency, which may differ between high and low altitudes. We analysed airborne birch and grass pollen concentrations along with allergen content (birch: Bet v 1, grass: Phl p 5) at two different altitudes (734 and 2650 m a.s.l.) in the Zugspitze region (2009–2010). Back-trajectories were calculated for the high altitude site and for specific days with abrupt increases in pollen potency. We observed several days with medically relevant pollen concentrations at the highest site. In addition, a few days with pollen were not associated with allergens and *vice versa*. The calculated seasonal mean allergen release per pollen grain was 1.8–3.3 pg Bet v 1 and 5.7 pg Phl p 5 in the valley and 1.1–3.7 pg Bet v 1 and 0.7–1.5 pg Phl p 5 at the high altitude site. Back-trajectories revealed that high pollen potency at the higher site was generally associated with south-westerly to south-easterly (birch), or northerly (grass) wind directions. By investigating days with sudden increases in pollen potency, however, it was difficult to draw definitive conclusions on long- or short-range transport. Our findings suggest that people allergic to pollen might suffer less at higher altitudes and further indicate that a risk assessment

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relying on the actual concentration of airborne pollen does not necessarily reflect the actual allergy exposure of individuals.

1. Introduction

Allergies are a major risk to human health. The World Health Organization (WHO) reported that 30–40% of the global population shows allergic sensitization (Pawankar et al., 2011). In Germany, 30% of the population are subject to allergies. Here, the most common allergy is the so-called hay fever that affects almost 15% of the population (Langen et al., 2013).

High altitude regions are believed to provide better conditions for people allergic to pollen (Charalampopoulos et al., 2013). Since temperature decreases with altitude phenological events and therefore the pollen season generally start later (Ziello et al., 2009). In addition, airborne pollen concentration is generally reduced with altitude (Markgraf, 1980; Clot et al., 1995; Gehrig and Peeters, 2000). However, local abundance of plant species can also cause higher concentrations at high altitude sites (Frei, 1997; Gehrig et al., 2011). Aguilera and Ruiz Valenzuela (2012) suggested that higher olive pollen amounts observed at elevated regions may be an intrinsic mechanism of these trees to compensate for limited pollination efficiency and a short growing period.

The degree to which allergic individuals react with symptoms does not only depend on pollen concentrations but also on the allergen content of the pollen (Buters et al., 2012). Whereas most studies, and also pollen forecasts, only evaluate the pollen concentration as daily averages of pollen per cubic meter of air (pollen grains/m^3), less attention has been paid to the pollen potency, the actual allergen release capacity of this pollen (allergen/pollen grain).

Regarding birch pollen, Schäppi et al. (1997) found an average allergen release of 6 pg Bet v 1/pollen grain in 1996 in Melbourne, Australia. Buters et al. (2012) reported a value of 3.2 pg Bet v 1/pollen grain which did not vary much between five European sites. Birch pollen of different years or regions was found to have an up to 5-fold difference in allergen release (Buters et al., 2008). In addition, 10-fold variations in Bet v 1 release were reported for different days within a single year. These variations were attributed to changes in the expression of Bet v 1 in the course of the pollen's maturation process reaching a maximum six days before pollination (Buters et al., 2010). Regarding grass pollen, Schäppi et al. (1999), for example, reported an allergen release of group 5 allergens in Melbourne of up to 14 ng/m^3.

Within this study we compared airborne pollen concentrations of birch (*Betula* ssp.) and grass (Poaceae) and their allergen content (Bet v 1 and Phl p 5) in 2009 and 2010 at Garmisch-Partenkirchen (GAP), located at 734 m a.s.l., and at the high alpine site Umweltforschungsstation Schneefernerhaus (UFS) at 2650 m a.s.l. A comparison of phenological and aerobiological data already revealed that the pollen season of birch and grass can be predicted by phenological observations and that temperature and wind conditions altered the characteristics of the pollen season at different altitudinal levels (Jochner et al., 2012). In order to assess the risk for people allergic to pollen, we now specifically identify days when severe hay fever symptoms can occur. To overcome limitations arising from forecasts based on pollen concentrations solely we evaluated pollen potency, its temporal change and its relation to meteorological data. Pollen data were analysed using back-trajectories in order to investigate the source regions that are associated with low/high pollen concentration/potency. In addition, we investigated the possible pollen origin for specific days which showed a sudden increase in pollen potency.

2. Material and methods

2.1. Monitoring sites

We sampled pollen at two sites in the Bavarian Alps – one located in the valley of GAP: 734 m a.s.l. (see Fig. 1). The pollen trap was outside of the city at a height of 2 m a.g.l. in a pasture, which was not cut during the pollen season. To the south of the city, mountainous slopes with mainly conifer forests stretch up to 1700 m a.s.l.

The second pollen monitoring site was located at UFS: 2650 m a.s.l. (see Fig. 1). Here, the pollen trap was placed on a terrace at 2 m a.g.l. The vertical distribution of birch is restricted to less than 1800 m a.s.l. in the Alps, allergenic grass species such as *Dactylis glomerata* L. (cocksfoot) and *Alopecurus pratensis* L. (meadow foxtail) grow up to an altitude of 1500–2000 m a.s.l. in the northern Alps (DWD, 1991). Thus, sampled birch and grass pollen at the UFS must originate from medium- (up to 100 km) and/or long-range (>100 km) transport.

2.2. Pollen monitoring

Pollen sampling was based on the standard equipment and methods proposed by the European Aeroallergen Network (EAN, Galán et al., 2014). Pollen was collected with Hirst-type seven-day recording volumetric pollen traps (Burkard Manufacturing Co. Ltd., UK) during the pollen seasons of 2009 and 2010. Pollen records had some gaps due to technical or organisational problems (see vertical lines in Fig. 2a–d and Fig. 3a–d).

Pollen counting was achieved with light microscopy along four longitudinal transects, representing ~10% of the slides according to the minimal requirements of EAN (Galán et al., 2014). Pollen were reported in the identical time frame as the allergen measurements, i.e., from midday of the current day to midday of the following day. The Pollen Index (PI) was defined as the total pollen detected during the sampling period of a given year. We focussed on grass pollen which is the major cause of pollinosis in many parts of the world and on birch pollen, the most important allergenic tree pollen in north, central, and eastern Europe (D'Amato et al., 2007). Symptom severity depends on pollen concentration (Durham et al., 2014). The threshold values which can cause hay fever symptoms (Table 1) are generally applied as a consensus but can vary regionally (de Weger et al. 2013) and might be influenced by other meteorological parameters. It is also important to note that these threshold values refer to the amount of pollen an individual is exposed to (e.g., while being outdoors).

2.3. Allergen sampling and analysis

We analysed the major allergen of birch (Bet v 1) and grass pollen (Phl p 5) in 2009 and 2010. Airborne allergen sampling was performed within 5 m of the pollen traps using a high-volume Chemvol® cascade impactor for the particulate matter (PM) sizes