Low CCN concentration events over the ENA: seasonality, meteorology and drivers

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Low CCN events in CAP-MBL (2009-2010)

- Defined as 6 hourly mean $N_{\text{CCN,0.1%}} < 20 \text{ cm}^{-3}$
- Total of 56 events occurring on 36 individual days
- Weak southerly flow associated with most events
- Link with marine cold air outbreaks

Climatology
Low CCN events

Wind Roses

Distribution of 5 min CCN concentrations (SS=0.1%)

See also ENA Site Science poster, Tuesday
Low CCN event

- Often associated with open cell structures over Graciosa

Seasonality of low CCN events

- 80% of low CCN events occur during winter and spring
Seasonal cycle: aerosol and cloud microphysics

Low submicron scattering during low CCN events

- Low events associated with factor of 2-3 reduction in submicron scattering
- Similar fractional reduction for total scattering (not shown), suggestive of reduced sea-spray aerosol
Low CCN events associated with development of synoptic scale low pressure to west and north of Azores

• Composite mean sea-level pressure (MSLP) for low CCN events 48 hr before low CCN events and at the start of events at Graciosa.
• Mean barbs indicate mean wind speeds in knots (full barb=10 kt; half barb=5 kt).
No systematic difference in LWP at Graciosa during low CCN events

- LWP pdfs not markedly different for low CCN and non-low CCN events
Fewer low clouds during low CCN events, more deep PBL clouds

Cloud droplet concentration reduced during low CCN events

Low CCN events often associated with cold air outbreaks

- Marine Cold Air Outbreak (MCAO) index $\mu = \theta_{\text{SST}} - \theta_{700}$
Air mass histories

- MODIS satellite observations interpolated onto back trajectories arriving at Graciosa
- Low CCN events show low $N_d$ several days upwind of Graciosa
- LWP enhanced for low CCN events 2-4 days prior to reaching Graciosa
- Coalescence scavenging loss rates scale strongly with $LWP (\sim LWP^2)$ and $LWP$ differences are sufficient to explain $N_d$ differences
148 hour back trajectories and MSLP for low CCN events
“Canonical low CCN event”
Summary

• Examined very low CCN events (<20 cm\(^{-3}\) CCN at 0.1% supersaturation) at Graciosa

• Low CCN events most frequent during winter and spring, often tied to cold air outbreaks

• Depletion of CCN in high LWP upstream of Graciosa, together with low wind speeds, may be key factors for formation of pristine air masses, but need information about other CCN source terms (e.g. free troposphere) is needed.
## Distinguishing characteristics of low CCN events

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>low CCN events</th>
<th>non-low CCN conditions</th>
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<tbody>
<tr>
<td>Seasonality</td>
<td>Three-quarters of events during DJF and MAM</td>
<td>Occur all year round</td>
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<tr>
<td>CCN concentrations (0.1%)</td>
<td>median 15 cm(^{-3}); 90% from 5-25 cm(^{-3})</td>
<td>median 80 cm(^{-3}); 90% from 25-215 cm(^{-3})</td>
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<tr>
<td>Aerosol scattering</td>
<td>Low values (both submicron and total) suppressed in approximate proportion to (N_{CCN,0.1}%)</td>
<td>Larger and more variable scattering</td>
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<tr>
<td>Wind direction (10 m) at Graciosa</td>
<td>Most cases from SW through SE.</td>
<td>Wide range of directions, many from SW clockwise through NW</td>
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<tr>
<td>Wind speed (10 m) at Graciosa</td>
<td>Median wind speed 3 m s(^{-1})</td>
<td>Median wind speed 5 m s(^{-1})</td>
</tr>
<tr>
<td>Back trajectory history</td>
<td>More trajectories experiencing cold air outbreak conditions</td>
<td>Fewer cold air outbreak encounters</td>
</tr>
<tr>
<td>Cloud droplet concentration (N_d)</td>
<td>20-50% lower (N_d) beginning several days upstream</td>
<td>Higher (N_d) beginning several days upstream</td>
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<tr>
<td>Liquid water path (LWP)</td>
<td>Little difference at Graciosa, but large values 2-3 days prior to trajectory arrival at Graciosa</td>
<td>Little difference at Graciosa; upstream distributions flat.</td>
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Additional slides
Aerosol scattering and CCN are well correlated

- Could base “pristine” case selection on scattering instead of CCN
- Case selection would not be identical, but many events would be the same