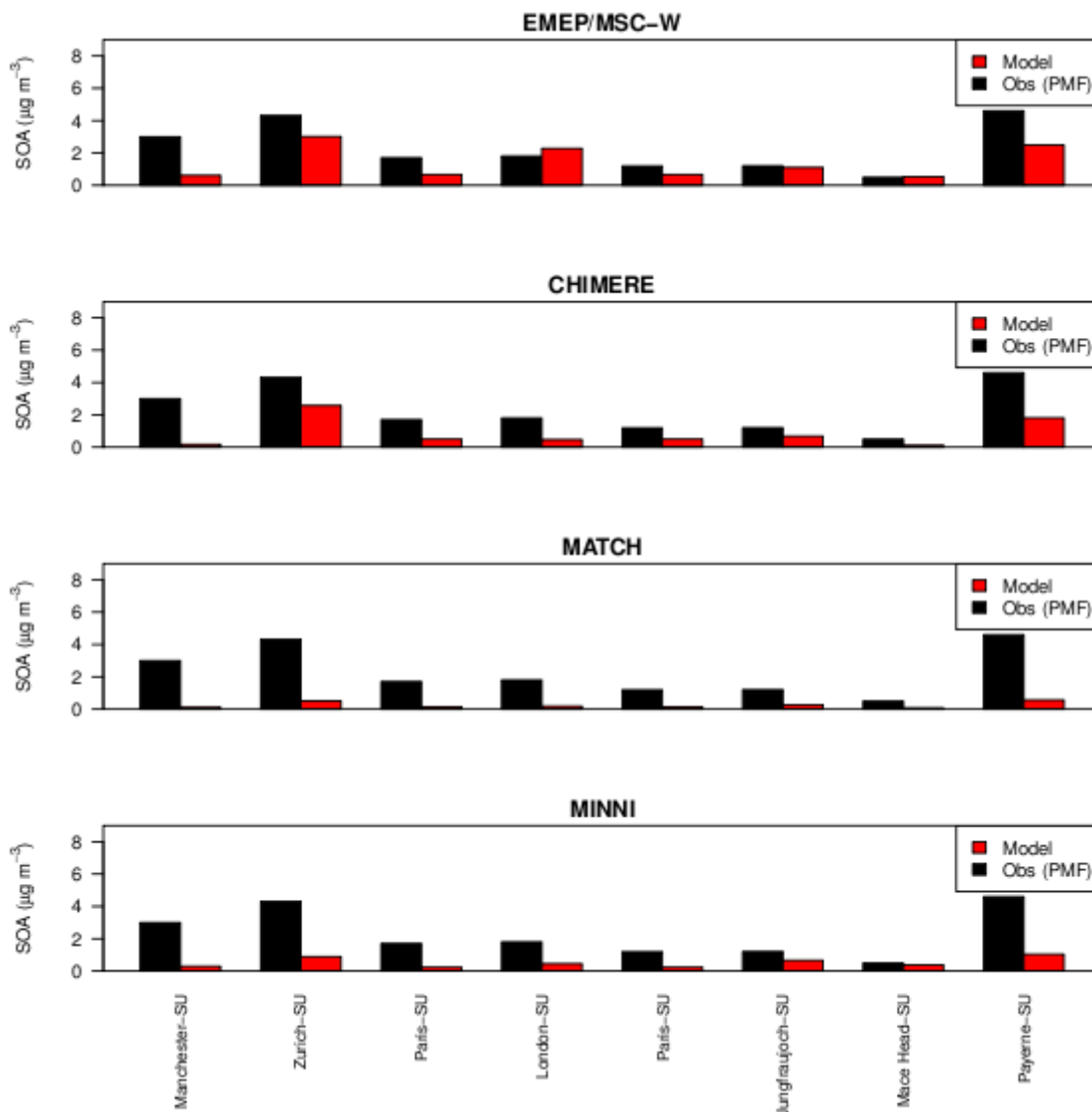


**Figure S1:** Spatial distribution of the observational sites for SOA (retrieved from PMF analysis). Total number of sites is 48. Sites with averages concentration above  $7 \mu\text{g m}^{-3}$  over the measuring period were excluded from the analysis. Information on the sites and periods of the measurements are reported in Table S2.



**Figure S2:** Modeled (red) and observed (black) SOA fraction at measurement stations during summer periods (8 sites).

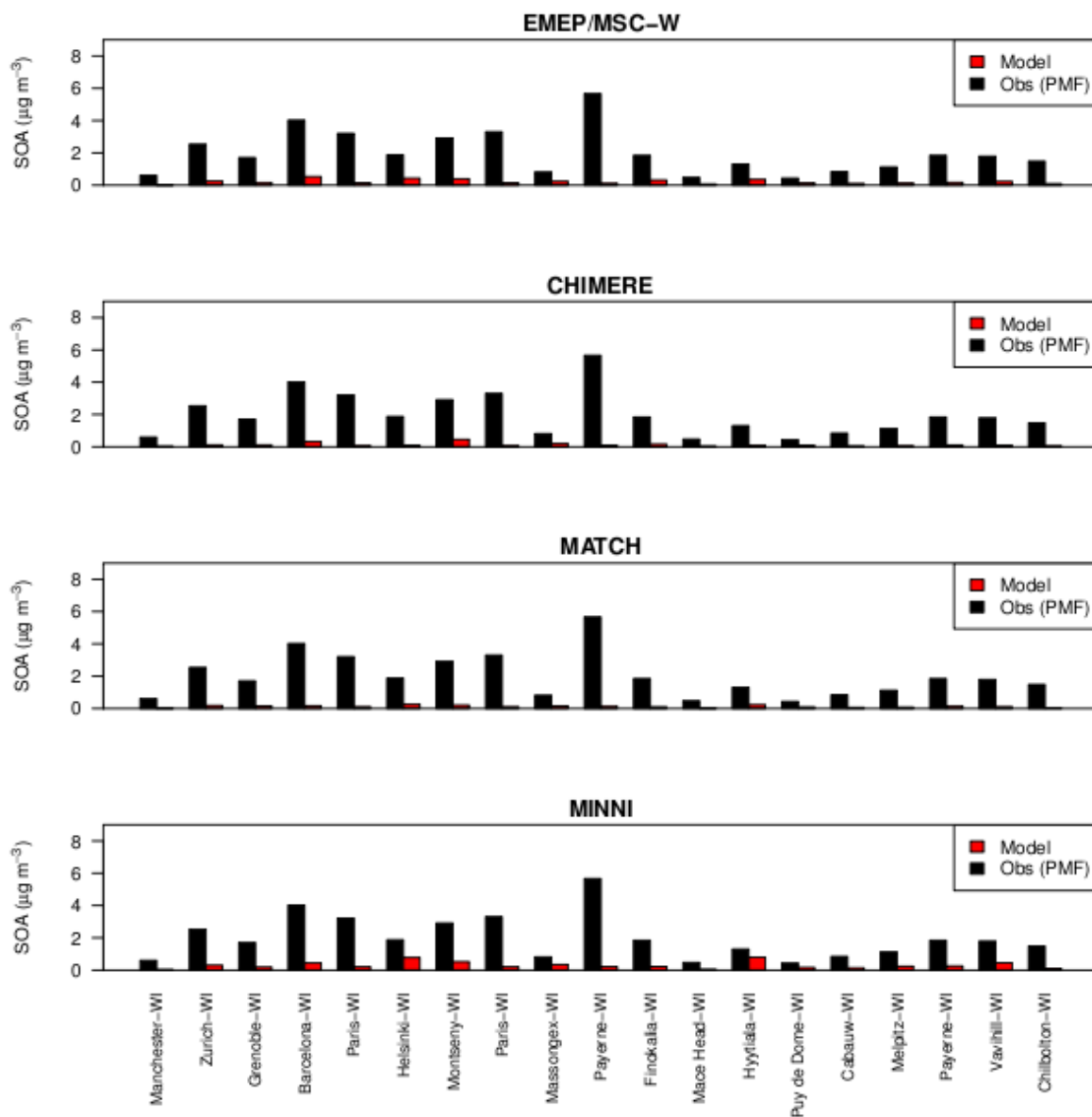
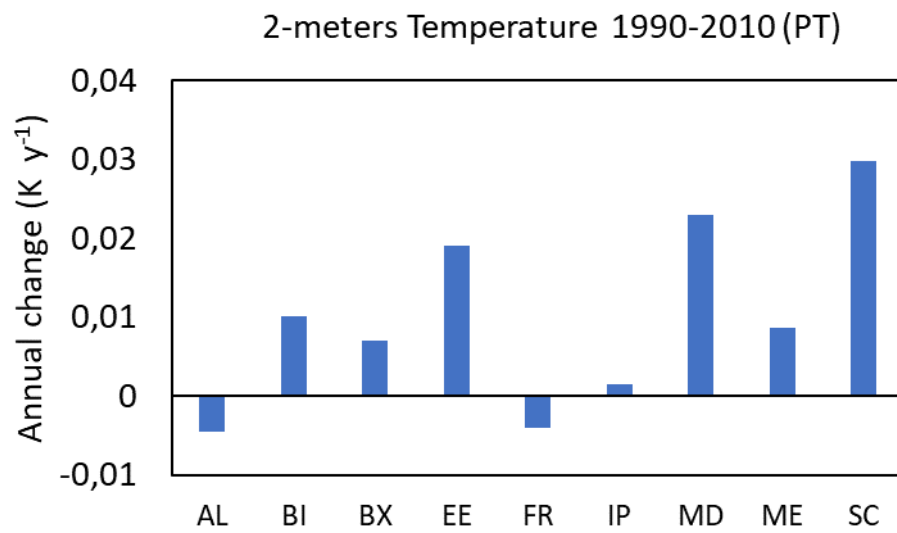


Figure S3: Modeled (red) and observed (black) SOA fraction at measurement stations during winter periods (19 sites).



**Figure S4:** Modeled absolute trends in 2-meters Temperature for the 1990–2010 (PT) period as available in ERA-interim forcing data for the different PRUDENCE zones (Figure 1).

**Table S1:** List of the EMEP stations available for the trends analysis for each investigated species (<https://wiki.met.no>). The numbers of observational sites are 30, 20, 25, 13 and 16 for SO<sub>2</sub>, SO<sub>4</sub><sup>2-</sup>, NO<sub>2</sub>, TNO<sub>3</sub> and TNH<sub>x</sub>, respectively.

| Stations | Latitude | Longitude | SO <sub>2</sub> | SO <sub>4</sub> <sup>2-</sup> | NO <sub>2</sub> | TNO <sub>3</sub> | TNH <sub>x</sub> |
|----------|----------|-----------|-----------------|-------------------------------|-----------------|------------------|------------------|
| AT0002R  | 47.77    | 16.77     | X               |                               |                 |                  |                  |
| AT0005R  | 46.68    | 12.97     | X               |                               |                 |                  |                  |
| BE0011R  | 51.02    | 2.58      |                 |                               | X               |                  |                  |
| BE0013R  | 51.25    | 3.35      |                 |                               | X               |                  |                  |
| BE0032R  | 51.46    | 6.00      |                 |                               | X               |                  |                  |
| CH0001G  | 46.55    | 7.99      | X               |                               |                 |                  |                  |
| CH0002R  | 46.81    | 6.94      | X               | X                             | X               |                  |                  |
| CZ0001R  | 49.73    | 16.05     | X               | X                             |                 |                  |                  |
| CZ0003R  | 49.58    | 15.08     | X               | X                             | X               |                  | X                |
| DE0001R  | 54.93    | 8.31      | X               |                               | X               |                  |                  |
| DE0002R  | 52.80    | 10.76     | X               |                               | X               |                  |                  |
| DE0003R  | 47.91    | 7.91      |                 |                               | X               |                  |                  |
| DE0005R  | 48.82    | 13.22     |                 |                               |                 |                  |                  |
| DE0007R  | 53.17    | 13.03     | X               |                               |                 |                  |                  |
| DE0044R  | 51.53    | 12.93     |                 |                               |                 |                  |                  |
| DK0003R  | 56.35    | 9.60      | X               | X                             |                 | X                | X                |
| DK0008R  | 56.72    | 11.52     | X               | X                             |                 | X                | X                |
| FI0004R  | 62.53    | 24.22     | X               |                               |                 | X                |                  |
| FI0009R  | 59.78    | 21.38     | X               | X                             |                 | X                | X                |
| FI0017R  | 60.53    | 27.69     | X               | X                             |                 | X                | X                |
| FI0022R  | 66.32    | 29.40     | X               | X                             |                 | X                | X                |
| FI0037R  | 62.58    | 24.18     |                 | X                             |                 |                  | X                |
| GB0014R  | 54.33    | -0.81     |                 |                               |                 | X                | X                |
| GB0037R  | 53.40    | -1.75     | X               |                               | X               |                  |                  |
| GB0038R  | 50.79    | 0.18      |                 |                               | X               |                  |                  |
| HR0002R  | 45.90    | 15.96     |                 |                               |                 |                  | X                |
| HU0002R  | 46.97    | 19.58     |                 |                               |                 | X                |                  |
| IE0001R  | 51.94    | -10.24    | X               | X                             | X               |                  |                  |
| IT0004R  | 45.80    | 8.63      | X               |                               | X               |                  |                  |
| LT0015R  | 55.35    | 21.07     | X               | X                             | X               |                  | X                |
| LV0010R  | 56.16    | 21.17     | X               |                               | X               |                  |                  |
| NL0009R  | 53.33    | 6.28      | X               |                               | X               |                  |                  |
| NL0010R  | 51.54    | 5.85      |                 |                               | X               |                  |                  |
| NO0001R  | 58.38    | 8.25      | X               | X                             | X               |                  | X                |
| NO0002R  | 58.39    | 8.25      |                 |                               |                 | X                |                  |
| NO0015R  | 65.83    | 13.92     | X               | X                             | X               |                  |                  |
| NO0039R  | 62.78    | 8.88      | X               | X                             | X               | X                | X                |
| NO0042G* | -        | -         | X               | X                             |                 |                  |                  |
| PL0002R  | 51.82    | 21.98     | X               | X                             | X               | X                |                  |
| PL0003R  | 50.73    | 15.73     | X               | X                             | X               |                  | X                |
| SE0002R  | 57.42    | 11.93     | X               |                               |                 |                  |                  |
| SE0005R  | 63.85    | 15.33     | X               | X                             | X               |                  | X                |
| SE0011R  | 56.02    | 13.15     | X               | X                             | X               | X                | X                |

|         |       |       |   |   |   |   |   |
|---------|-------|-------|---|---|---|---|---|
| SE0014R | 57.39 | 11.91 |   | X | X | X | X |
| SK0002R | 48.93 | 19.58 | X | X | X |   |   |

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\*Available in the data-set but outside the modeling domain.

**Table S2:** List of stations used for the SOA evaluation. The total number of stations retrieved for Europe from the Tsimpidi et al., 2016 study is 48. Observational sites with average concentrations above  $7 \mu\text{g m}^{-3}$  over the measuring period were removed from the analysis.

| Site               | Year | Latitude | Longitude | Season |
|--------------------|------|----------|-----------|--------|
| Barcelona-WI       | 2009 | 41.39    | 2.12      | Winter |
| Cabauw-SP          | 2008 | 51.97    | 4.93      | Spring |
| Cabauw-WI          | 2009 | 51.97    | 4.93      | Winter |
| Chilbolton-WI      | 2009 | 51.1     | -1.40     | Winter |
| Finokalia-SP       | 2008 | 35.33    | 25.66     | Spring |
| Finokalia-WI       | 2009 | 35.33    | 25.66     | Winter |
| Grenoble-WI        | 2009 | 45.18    | 5.73      | Winter |
| Harwell-AU         | 2008 | 51.15    | -1.44     | Autumn |
| Helsinki-SP        | 2009 | 60.2     | 24.95     | Spring |
| Helsinki-WI        | 2009 | 60.2     | 24.95     | Winter |
| Hohenpeisseberg-SP | 2002 | 47.8     | 11.00     | Spring |
| Hyytiälä-AU        | 2008 | 61.8     | 24.3      | Autumn |
| Hyytiälä-SP        | 2003 | 61.8     | 24.3      | Spring |
| Hyytiälä-SP        | 2005 | 61.8     | 24.3      | Spring |
| Hyytiälä-WI        | 2009 | 61.8     | 24.3      | Winter |
| Jungfraujoch-SU    | 2002 | 46.3     | 7.6       | Summer |
| Jungfraujoch-SU    | 2008 | 46.3     | 7.6       | Spring |
| K-Pustza-AU        | 2008 | 46.96    | 19.58     | Autumn |
| London-SU          | 2003 | 51.7     | 0.4       | Summer |
| Mace head-SP       | 2008 | 53.3     | -9.80     | Spring |
| Mace Head-SU       | 2002 | 53.3     | -9.80     | Summer |
| Mace Head-WI       | 2009 | 53.3     | -9.80     | Winter |
| Mainz-AU           | 2004 | 49.98    | 8.23      | Autumn |
| Manchester-SU      | 2001 | 53.5     | -2.22     | Summer |
| Manchester-WI      | 2002 | 53.5     | -2.22     | Winter |
| Massongex-WI       | 2006 | 46.24    | 6.14      | Winter |
| Melpitz-AU         | 2008 | 51.54    | 12.93     | Autumn |
| Melpitz-SP         | 2008 | 51.54    | 12.93     | Spring |
| Melpitz-WI         | 2009 | 51.54    | 12.93     | Winter |
| Montseny-WI        | 2009 | 41.76    | 2.4       | Winter |
| Norfolk coast-SP   | 2004 | 53       | 1.1       | Spring |
| Paris-SU           | 2009 | 48.83    | 2.36      | Summer |
| Paris-SU           | 2009 | 48.72    | 2.21      | Summer |
| Paris-WI           | 2010 | 48.83    | 2.36      | Winter |
| Paris-WI           | 2010 | 48.72    | 2.21      | Winter |
| Payerne-AU         | 2008 | 46.8     | 6.95      | Autumn |
| Payerne-SU         | 2006 | 46.8     | 6.95      | Summer |
| Payerne-WI         | 2007 | 46.8     | 6.95      | Winter |
| Payerne-WI         | 2009 | 46.8     | 6.95      | Winter |
| Po Valley-SP       | 2008 | 44.65    | 11.62     | Spring |
| Puijo-AU           | 2008 | 62.9     | 27.65     | Autumn |
| Puy de Dome-AU     | 2008 | 45.77    | 2.97      | Autumn |
| Puy de Dome-WI     | 2009 | 45.77    | 2.97      | Winter |
| San Pietro-SP      | 2008 | 44.65    | 11.65     | Spring |

|             |      |       |       |        |
|-------------|------|-------|-------|--------|
| Vavihill-AU | 2008 | 56.02 | 13.15 | Autumn |
| Vavihill-WI | 2009 | 56.02 | 13.15 | Winter |
| Zürich-SU   | 2005 | 47.4  | 8.5   | Summer |
| Zürich-WI   | 2006 | 47.4  | 8.5   | Winter |

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