Site Descriptions

1. Acadia National Park, Maine, USA (ACA)

Acadia National Park is an IMPROVE site on the north-eastern coast of the United States very close to the Atlantic ocean. The region is forested with both pine and deciduous trees. More information about ACA can be found on the National Park Service website (http://www.nps.gov/acad). The ACA data were screened using the criteria s_{sp}<500 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at ACA.

2. Big Bend National Park, Texas, USA (BBE)

Big Bend National Park is an IMPROVE site in the central southern United States. It is classified as a desert site, although the region contains rivers and mountains as well. More information can be found on the National Park Service website (http://www.nps.gov/bibe). BBE was the location for the Big Bend Regional Aerosol and Visibility Observational (BRAVO) Study in 1999 investigating causes and sources of visibility reduction in the park [Malm et al., 2003]. The BBE data were screened using the criteria s_{sp}<100 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at BBE.

3. Bondville, USA (BND)

The Bondville surface site in Illinois is operated by the Illinois State Water Survey and aerosol optical property measurements have been made at the surface site by NOAA since 1996 [Delene and Ogren, 2002]. The site is located in a rural agricultural area, relatively remote (>250 km) from large cities such as Chicago. Hygroscopicity of the aerosol at BND has been investigated by Koloutsou-Vakakis et al. [2001]. There is an IMPROVE site co-located at BND, but it only makes chemical measurements, there is not an IMPROVE nephelometer at BND. The BND aerosol inlet system has remained the same over the period of measurement, however there have been several internal plumbing changes as the aerosol rack was re-arranged. These changes do not appear to have had a noticeable affect on the data. The current instrument installation at BND is similar to that described in Sheridan et al. [2001]. The PSAP was upgraded from a 1-wavelength to 3-wavelength instrument in February 2006. There is no wind sector screening at BND.

4. Barrow, USA (BRW)

Barrow is a coastal arctic site. NOAA has been making aerosol measurements there since the mid-1970s [Bodhaine 1983; Bodhaine 1995]. Aerosol concentrations tend to be highest in winter/spring during the Arctic haze season and very clean in the summer [Delene and Ogren, 2002; Quinn et al., 2002]. Occasional incursions of smoke from forest fires in Russia and North America and dust from Asia have also been observed [Stone et al., 2007; Stone et al., 2008]. Because it has been

suggested that the Arctic may be more sensitive to changes in climate, there have been several investigations of aerosol trends based on the measurements made at Barrow [e.g., Quinn et al.2007; Quinn et al., 2009; Sharma et al., 2006]. Nephelometer measurements at BRW began in 1976 and absorption measurements with an aethalometer began in 1988. However, due to inlet and instrument changes we only include scattering and absorption measurements after October 1997 in this study. The current instrument installation at BRW is similar to that described in Sheridan et al. [2001]. The PSAP was upgraded from a 1-wavelength to 3-wavelength instrument in June 2006. There is wind sector screening at BRW; data sampled when the wind is from the polluted sector sector which includes the town of Barrow are not included in the analysis.

5. Finokalia, Greece (FKL)

Finokalia is a remote coastal site in the northeast part of the island of Crete; a description of the site is given by Mihalopoulos et al. [1997]. The site is primarily influenced by long range transport of anthropogenic aerosol from Europe and Asia and dust aerosol from Africa. A climatology of aerosol optical properties at the site has been presented by Kalivitis et al [2011]. Some other aerosol references for Finokalia are Querol et al. [2009], Vrekassis et al. [2009], and Gerasopoulos et al. [2006]. There are two sets of nephelometer measurements at FKL: a dry (RH controlled) scattering measurement and an uncontrolled scattering measurement. Here we have used the uncontrolled (or wet) scattering measurement as it is a longer time series. There is no wind sector screening at FIK.

6. Great Smoky Mountain National Park, Tennesee, USA (GSM)

Great Smoky Mountain National Park is an IMPROVE site in the eastern United States. The word 'smoky' in the name comes from the frequent fogs due to transport of warm, moist air from the Gulf of Mexico to the cooler mountainous terrain of the southern Appalachians. It is a forested hilly area with abundant precipitation and high humidity, especially in the summer months. More information can be found on the National Park Service website (http://www.nps.gov/grsm/). GSM was the site of the South-Eastern Aerosol and Visibility (SEAVS) Campaign in 1995 and investigations of mass and scattering closure have been performed on measurements at the site [e.g., Andrews et al.,2000; Hand et al., 2000; Hand et al., 2002] and an additional study in 2006 to investigate issues related to calculating light extinction from chemical measurements [e.g., Lowenthal et al., 2009]. The GSM data were screened using the criteria σ_{sp}<500 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at GSM.

7. Hance Camp at Grand Canyon National Park, Arizona, USA (HGC)

HGC is in Grand Canyon National Park. The landscape is semi-arid and consists of plateaus and deep canyons. More information about the Grand Canyon National Park can be found at the National Park Service webpage (http://www.nps.gov/grca/). The HGC data were screened using the criteria σ_{sp}<100 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at HGC.

8. Hohenpeissenberg, Germany (HPB)

The observatory is located at about 300m elevation above the surrounding area in a rural region with significant agricultural activity. Particle number concentrations at HPB peak in summer and are lowest in winter, while particle mass concentrations tend to be highest in spring and lowest in winter [Held et al., 2008]. Held et al. [2008] also show that wind direction influences the aerosol observed at HPB; wind from the NE can transport anthropogenic aerosol from Munich, however there is no wind sector screening at HPB. The instruments described here were on a whole air inlet from the start of measurement until 2007. In 2007 the inlet size cut was changed to PM10. A second nephelometer is currently running on a whole air inlet for side by side comparison of scattering measurements for the two inlets. Some references describing HPB aerosol data are: Putaud et al., [2010]; Paasonen et al. [2010]; Reddington et al., [2011]; Asmi et al., [2011]. With the exception of Putaud et al. [2010], these references describe number concentration data. Putaud et al. [2010] presents ionic mass concentrations for many European sites including HPB.

9. Ike's Backbone, Arizona, USA

IBB is in the Mazatzal Wilderness in central Arizona. It is a desert landscape with rugged terrain (ravines and hills). The IBB data were screened using the criteria $s_{sp}<100$ Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at IBB.

10. Jungfraujoch, Switzerland (JFJ)

The Jungfraujoch high alpine research station is a Global Atmospheric Watch (GAW) global station. Routine measurements of aerosol optical properties at JFJ began in 1995, although other aerosol properties were measured before that time [e.g., Baltensperger et al., 1991]. Throughout the year the station is within clouds about 40% of the time. Therefore, ambient air is sampled from a total inlet, heated to 25°C in order to evaporate cloud hydrometeors and to sample both their residual particles and the interstitial particles [Weingartner et al., 1999]. Observations of the seasonal cycle of various aerosol parameters have found a minimum in winter and maximum in summer [Collaud Coen et al., 2011 and references therein]. JFJ can be considered as being in the FT during the entire day in winter; in spring during periods of synoptic subsidence it is influenced by planetary boundary layer air in the afternoon; and during summer boundary layer air systematically reaches the JFJ altitude during the afternoon, whereas the station stays in the FT during night apart from synoptic subsidence cases. The complex terrain and meteorology at JFJ mean that wind sector cannot be used to segregate FT air from PBL air, therefore no wind sector flagging is done. Prior to 2001 a broadband aethalometer was used to characterize absorbing aerosol at JFJ, however due to discontinuities in the data set following installation of a 7 wavelength aethalometer only data from the 7 wavelength instrument are used here. The location of the measurements changed in 1998 from the original station to the Sphinx station, but careful inspection of the data suggest this move did not induce any breakpoints in the data. Because of the long time series of data available at JFJ, Collaud Coen et al. [2007] were able to examine long term trends in aerosol optical properties – this trend analysis extended here with an additional 5 years of data. Andrews et al. [2011] present climatologies of the free troposphere aerosol optical properties at JFJ based on 1995-2007 data.

11. Mammoth Cave National Park, Kentucky, USA (MCN)

MCN is in the hilly region of south central Kentucky. Climatologically it will be quite similar to GSM and SHN. More information can be found on the National Park Service website (http://www.nps.gov/maca/). The MCN data were screened using the criteria σ_{sp}<500 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at MCN.

12. Mace Head, Ireland (MHD)

Mace Head is a clean marine background site on the west coast of Ireland. Super-micron sea salt dominates the measured scattering during the winter due to low biological activities and high wind speeds, while in the summer sub-micron biogenic organic aerosol is more prevalent. Long-range transport of regional anthropogenic aerosol has been observed as has incursions from aerosol events (e.g., volcanic ash, forest fires). Cooke et al. [1997] report that absorption in marine air peaks in late spring, while continental air has two peaks in February and May due to higher wintertime emissions and lower precipitation. Segregation of data into 'marine' and 'continental' is done primarily by wind direction and black carbon mass concentration level. This segregation information must be obtained from the data providers - it is not available in the WDCA/EBAS data base. Other papers describing aerosol measurements at MHD include: Vaishya et al. [2012], O'Connor et al. [2008], Cooke et al. [1997], and Jennings et al. [2003].

13. Mauna Loa, USA (MLO)

The Mauna Loa Observatory was established in 1956 on the island of Hawaii as a site for atmospheric and meteorological measurements. The National Oceanic and Atmospheric Administration (NOAA) Geophysical Monitoring for Climatic Change (GMCC) program (now the NOAA Earth System Research Laboratory (ESRL) Global Monitoring Division) began long term monitoring of aerosol light scattering at MLO in 1974 and light absorption in 1990. Bodhaine [1983] and Bodhaine [1995] present time series of the first eight years of light scattering and light absorption at MLO and note a strong seasonal cycle where higher scattering and absorption are observed in the springtime. These peaks were attributed to long-range transport of Asian dust and pollution [e.g., Perry et al., 1999]. Andrews et al. [2011] present climatologies of the free troposphere aerosol optical properties at MLO based on 2000-2009 data. Due to inlet and instrument changes we only include scattering and absorption measurements from 2001 onward in this study. The current instrument installation at MLO is similar to that described in Sheridan et al. [2001]. The PSAP was upgraded from a 1-wavelength to 3-wavelength instrument in September 2006. There is wind sector screening at MLO; data sampled when the wind is from the upslope sector are not included in the analysis.

14. Mount Rainier National Park, Washington, USA (MRN)

MRN is located in Mount Rainier National Park. The landscape consists of temperate forest with steep mountains and many rivers. More information about MRN can be found on the National Park Service website (http://www.nps.gov/mora/). The MRN data were screened using the criteria σ_{sp}<100 Mm^{-1} to eliminate issues with

precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at MRN.

15. Mount Zirkel Wilderness, Colorado, USA (MZW)

The Mount Zirkel Wilderness lies within the Routt National Forest in the Rocky Mountains in northwestern Colorado. More information about MZW can be found at http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=391 The site is a high altitude site, but is influenced by regional transport of vehicular, power plant and biomass burning (both from domestic heating and forest fires) emissions [Watson et al., 1996]. The MZW data were screened using the criteria σ_{sp}<100 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at MZW.

16. Neumayer, Antarctica (NMY)

NMY is a year round sampling site on an Antarctic ice shelf. Aerosol properties have been sampled at NMY since 1981. Sea salt is the main aerosol component throughout the year, but other aerosol species (e.g., sulphate, nitrate) have quite obvious seasonal cycles [Weller et al., 2011a]. The cycles in CN are similar to those observed for sulphate and nitrate Weller et al. [2011b], while aerosol scattering has a broad peak over Austral winter and appears is likely strongly influenced by sea salt [Weller and and Lampert, 2008]. Contaminated data are flagged - the contamination occurs when air comes from the sector containing the main station.

17. Pallas, Finland (PAL)

Pallas is located in a sub-arctic forest in northern Finland. There is a summer maximum in scattering and an autumn minimum. The PAL data are screened for cloud contamination. There have been several inlet size cut changes at PAL (2000-2006: 7um size cut; 2006-2008: 2.5 μm size cut; and 2008-present:PM10), however the size cuts do not appear to cause a rupture in any data sets, presumably because the PAL aerosol is dominated by sub-micron aerosol. An overview of PAL measurements of the PAL measurements is presented by Hatakka et al. [2003] while a climatology of the optical properties of the PAL aerosol is provided in Aaltonen et al. [2006]. Black carbon measurements in Finland (including PAL) are described by Hyvarinen et al. [2011].

18. Phoenix, Arizona, USA (PAZ)

PAZ is a suburban site on the outskirts of Phoenix, Arizona. Sorooshian et al. [2011] looked at trends in aerosol chemistry and mass for PAZ, SCN and SIA as part of a climatology of southern Arizona. The PAZ data were screened using the criteria σ_{sp}<100 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at PAZ.

19. Sycamore Canyon, Arizona, USA (SCN)

The SCN site is in a remote, rather inaccessible red rock canyon with several tributaries, surrounded by a wooded plateau. Sorooshian et al. [2011] looked at trends in aerosol chemistry and mass for PAZ, SCN and SIA as part of a climatology

of southern Arizona. The SCN data were screened using the criteria σ_{sp}<100 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at SCN.

20. Southern Great Plains, USA (SGP)

The Southern Great Plains surface site in rural Oklahoma is operated by the US Department of Energy (DOE). The measurements of aerosol optical properties have been on-going since 1996 and are a collaboration between NOAA and DOE. Climatology of the surface in-situ aerosol at SGP has been described by Sheridan et al. (2001) and Delene and Ogren (2002). The current instrument installation at SGP is similar to that described in Sheridan et al. [2001]. The PSAP was upgraded from a 1-wavelength to 3-wavelength instrument in April 2005, however due to RH control effects in the PSAP sample line the absorption data are not used in this study. There is no wind sector screening at SGP.

21. Shenandoah National Park, Virginia, USA (SHN)

SHN is located in the eastern US approximately 200 km southwest of Washington, D.C. Like Great Smoky National Park, Shenandoah National Park is also located in the southern Appalachian mountain range. It is a humid, forested landscape. More information can be found on the National Park Service website (http://www.nps.gov/shen/. The SHN data were screened using the criteria σ_{sp}<500 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at SHN.

22. Sierra Ancha, Arizona, USA (SIA)

The terrain in the vicinity of SIA varies from box canyons to high cliffs and pine-covered mountains. Elevations range from lows of about 4,000 feet (1,200 m) to a high of 7,733 feet (2,357 m) at Aztec Peak, ranging from Saguaro cactus-studded desert to pine-forested mountains. Sorooshian et al. [2011] looked at trends in aerosol chemistry and mass for PAZ, SCN and SIA as part of a climatology of southern Arizona. The SIA data were screened using the criteria σ_{sp}<100 Mm^{-1} to eliminate issues with precipitation, but no other flagging criteria were available for the data set available from WDCA/EBAS. There is no wind sector screening at SIA.

23. South Pole, Antarctica (SPO)

South Pole is a high altitude Antarctic site. NOAA has operated aerosol instruments at SPO since the 1970s [Bodhaine, 1983; Bodhaine, 1995]. Scattering measurements began at SPO in 1979 with a 4-wavelength MRI nephelometer, Those measurements are not included here as they need to be rescreened and the potential for a rupture in the data set is large. The nephelometer measurements included here date from the installation of a TSI nephelometer in late 2002. SPO is a very clean site, however construction over the last several years has resulted in noticeable increases in aerosol number concentration [Asmi et al., 2012]. There is wind sector screening at SPO; data sampled when the wind is from the polluted sector containing the main station and living quarters are not included in the analysis.

24. Trinidad Head, California, USA (THD)

Trinidad Head is a coastal site in northern California (~400 km northwest of San Francisco). In 2002, the Intercontinental Transport and Chemical Transformation (ITCT) marked the start of measurements at THD. Atmospheric gases and aerosol properties were studied as part of this effort [e.g., Allan et al., 2004]. Currently a climatological analysis of the first 10 years of THD data is being performed. The THD aerosol inlet system has remained the same over the period of measurement, however there have been several internal plumbing changes as the aerosol rack was re-arranged. These changes do not appear to have had a noticeable effect on the data. The current instrument installation at THD is similar to that described in Sheridan et al. [2001]. The PSAP was upgraded from a 1-wavelength to 3-wavelength instrument in October 2006. There is no wind sector screening at THD.

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