1. Welcome and Introductions

- See Attendance List for list of attendees, their organization and email addresses.
- Selma Isil was introduced as the new AMSC secretary.

2. Approval of October, 2021 meeting minutes

- The minutes file was corrupted during a power failure. The October 2021 meeting minutes will have to be approved at a later date.

3. Recap of Activities since October

- AMSC committee was renewed in early November for four more years of operation.
- Field monitoring for the methods comparison study concluded late fall 2021. Data crunching and analyses have been ongoing since then with an initial draft report.
- Pollen Counts, a non-profit group from Iowa, has reached out to Andy, David and Jamie. Goals and mission very similar to AMSC's. Several calls have taken place.
- Connected with Yang Liu from Emory and he will present today
- Also engaged with Fiona Lo at University of Washington and she will also present some of her work.
- Jamie and David asked Andy to give presentation to WSLH Board of Directors as to why monitoring for aero allergens is important.

4. Update on Pilot Study for Aeroallergen Monitoring within the NADP (David Gay, Greg Wetherbee, Andy Johnson, Eric Uram, Terri Williams, and Alexandra Kois)

- This study compares four different monitoring methods for collecting pollen:
  1) Daily Rotorod: air sample collected on sticky slide or probe; sample stained; identified and counted visually by human.
     - Shortcomings are: small network (only 90 sites in US); slow turnaround of Information or not released at all; only in cities and no collection on weekends, expensive, only identifies to the genus level.
     - However, the rotorod is considered the "gold standard" for pollen measurements.
  2) Weekly Total Suspended Particulate: collected on high volume air sampler filter, sample stained and manual visual microscopy, i.e. identified and counted visually by human.
  3) Weekly wet deposition: the collected precipitation sample is filtered for solids, pollen stained, and identified and counted visually by human.
     - Shortcomings are: actually measuring column of air rather than just at the surface;

only measuring when it rains and not necessarily capturing surface air like the traditional method; and can only identify to genus level.
- However, 250+ sites that can be used for sampling, and weekly measurements.

4) Continuous PollenSense (PS): new optical method. A microscopic image of air sample collected on sticky tape is uploaded to PS on the internet and samples are identified by artificial intelligence (AI).

- Pollen monitoring is important because of health implications.
  - More than 50 million Americans experience various types of allergies each year;
  - Allergies are the 6th leading cause of chronic illness;
  - Annual cost of dealing with allergies exceeds $18 billion;
  - Asthma can be triggered by allergies;
  - There is a climate change connection in that spatial and temporal shifts in plant airborne pollen loads can be a climate change indicator. Also, amount of pollen may be increasing due to increasing temperature and available CO_2 for uptake. All of this will lead to increasing health impacts.
- Current pollen monitoring is relatively modest, spatially limited, costly and time consuming with much of the collected data unavailable freely for medical or research use. The data are also not real-time measurements.
- Key Questions to answer with this study are:
  1) Can NADP samples be used to estimate pollen levels at NADP sites as a normal part of the NADP sample processing?
  2) How do NADP samples compare to other methods?
- Some overall conclusions thus far:
  1) There is pollen in all of the systems;
  2) Pollen concentrations are present in highly variable concentrations with hour by hour variation;
  3) Season seems to start earlier than what is currently known as the start of pollen season (late March);
  4) Concentrations are correlated but there is lots of variability;
  5) The best correlation is between the National Allergy Bureau (NAB)/Medical and the PS.
- Preliminary Conclusions on the NTN Wet Deposition Measurements:
  1) Moderately correlated with HiVol, Rotorod and PS;
  2) The measurement system does work;
  3) Limited by the proficiency of human counters; note enough experience yet;
  4) Expensive due to time involved ‘reading’ a filter;
  5) Provides general information for occurrence times and long-term concentration averages and trends;
  6) Will require further training;
  7) Using the regular filtration filters is possible but translucent filters are best;

8) Not sure if the NTN approach will add much to the national picture.

- More specific conclusions:
  1) Variations in PS and rotorod data are similar;
  2) Daily mean PS and rotorod pollen counts are modestly correlated;
  3) Measurement correlations improve with increasing proximity of stations;
  4) NTN precipitation filters can be used to detect shifts in the pollen season but only during periods with precipitation;
  5) HVAS results are weakly correlated to other methods, but filter loading makes counting challenging;
  6) Correlations between various methods may shift seasonally;
  7) Re-Analysis for QC purposes showed similar results that were encouraging for further development of NTN filter-counting methods;
- The NADP recommends engineering modifications to the PS instruments, site support and QA. Some examples of these are:
  1) Replace intake fan with an air pump similar to an HVAS;
  2) Eliminate stray particulates inside the units;
  3) Re-evaluate the power supplies;
  4) Tape tears and can bubble up.
- Other Thoughts:
  1) Improve siting criteria as they are important;
  2) The PS has good potential for agricultural pathogen warning system;
  3) NAB data not very detailed by species but adequate for this study; NAB data were easier to obtain than expected, but still not easy;
  4) Both PS and NAB data are being used to represent ~~are predicting~~ pollen concentrations over very large areas, whereas this study shows proximity matters. NADP could fill gaps but probably only for phenology monitoring, not public health;
  5) Air quality monitoring networks could expand both NAB and PS networks by collocating sampling/sensors at NADP, CASTNET, NCore, and other network sites with power, internet and weekly site operator visits;
  6) Continue to work through AMSC to expand pollen monitoring and make data publicly available.
- Lessons learned with PS and Other Instruments (Eric Uram)
  1) Measuring flow: Was very difficult and not very scientific. Preference would be to see some sort of pump system in the PS;
  2) All systems had issues with tape: tearing; tape would not advance properly; smoke issue in Utah had deleterious effect; bubbles were appearing in the tape itself; tape pulled off of tape spool;
  3) Dust inside system. Don't know if pollen or not;
  4) Maintenance is fairly simple. Tape spool lasts 35 days;
  5) Problems with unit can be seen remotely; big advantage over NAB;

6) Plastic particles are now being read as well;
7) HiVol used 24/7 but not sure if it ran all the time; found shut down once. Could measure flow and volume going thru filter.

- Measuring Technique and Issues: (Terri:Williams)

1) Needed to figure out how to filter sample and how to best stain the filter;
2) It was good to experiment with ample rain samples;
3) Was hard to find glass slide and cover slip for size of entire filter;
4) Three micron clear filters work best;
5) How to actually give a count once under microscope: chose to use a random field count while looking at 10% of the slide; was best that can be done in time allotted. It takes 30 minutes to read a light count slide and from 1 to 1.5 hours for heavy count slide. Motorized stage would be ideal;
6) Broken pollen pieces were also recorded (question from Fiona). Cedar pollen vey hygroscopic and will explode easily. So this is an issue when collecting sample in water.

5. Comparison of APS Pollen Sensor Data with Burkard Counts in Munich, Germany (Landon Bunderson)

- Autopollen is a study put on by eumetnet. They do phenological studies and are interested in automation of pollen counting.
- Study conducted on rooftop in Munich Germany from March through September 2021
- Four Burkards were deployed side by side by side by side and 1 APS from PollenSense and other automated pollen counter sensors from Europe.
- No changes to Pollensense during duration of study.
- Were only given raw data by eumetnet and it was up to APS to analyze; but did not get all raw data but rather the means of Burkard samplers (manual samplers) and standard deviations.
- Burkard collectors often had a high degree of variability.
- The R2 from the sum of daily average correlations of hourly counts was 0.38 between Burkard and APS.
- Birch pollen was one of the highest counted pollen types and had a good R2 value of 0.795; easy pollen type to ID.
- Pine R2 value was 0.74; pine pollen also very distinctive with air bladders attached to the grain.
- Ash (Fraxinus) pollen also distinctive with an R2 of 0.61.
- R2 for rest of pollen types ranged from 0 for Fagus (only 3 pollen grains) to 0.31 for Populus.
- Pollen types included: Alder (alnus) but not much in the air, Fagus, Poaceae (grass pollen), plantago (lots of false IDs of this), quercus, and urtica; the populus value is

being disregarded as there was a difference in amount sampled. APS measured much higher.

- They train algorithms for the region and have multiple vision model segments.
- American Oak pollen (Quercus rubra) versus European oak pollen (Quercus ilex) have slight visual differences.

6. Field Evaluation of a Low-Cost Real-Time Pollen Sensor (Yang Liu)

* Motivation for study: Even though pollen exposure is a major driver of respiratory illness affecting tens of millions of people and resulting in billions of dollars in medical costs, very little is known to date about how pollen is spatially distributed at a finer scale. Also, pollen counts in the U.S. are only monitored in select cities using a manual counting method.

- Study Objective: To evaluate the accuracy and consistency of a new fully automated pollen sensor against current gold-standard measurements in Atlanta.
- Conventional pollen counting requires a NAB certified lab and technicians to operate.
- The APS300 Pollen Sensor consists of:
  - Tape feed for continuous and adaptive pollen collection;
  - Microscope with lighting and focus mechanisms;
  - Airflow system with inlet nozzle and fan;
  - Custom controller board and embedded computer; and
  - Housing with vibration isolation.
- Images are uploaded in real time to cloud server and PollenSense's proprietary AI algorithm ID's pollen, mold, and inorganic particles greater than 5 microns in diameter. Pollen counts are calculated based on the flow rate and hardware specifics.
- Study was conducted at three sites (Marietta, downtown Atlanta, and Oak Grove neighborhood) from March 2020 to December 2020 and from March 2021 to current.
- A PurpleAir air quality sensor was deployed along with the PollenSense instrument.
- Statistical analysis consisted of comparison with the gold-standard in Marietta for 2020 data. Gold-standard data for 2021 not available until December 2022.
- Average daily pollen concentrations show strong positive correlation between the two methods (NAB vs APS-300) in the spring and weak correlation in the fall. The highest correlation was for ragweed.
- Many tree species showed strong correlation with oak, pine, ash and mulberry having the highest correlations (0.86, 0.85, 0.71 and 0.76, respectively). Ragweed was the only non-tree species that had a good correlation of 0.72.
- Both methods ID'ed a similar set of major tree species, but not identical. The APS-300 also ID'ed mulberry as a major tree species. Chenopodium (goosefoot) and Poaceae (lawn grass) were only ID'ed by the APS-300.
- Colocated PollenSense instruments showed good precision with an R2 of 0.98. One unit measured higher concentrations than the other when counts were at peak level.

- Spatial contrasts were observed among the three sites with all three sites having the same peak periods but with different individual peaks and time patterns.
- Pollen counts were positively correlated with temperature and boundary layer heights and negatively correlated with relative humidity.
- All three sites shared a diurnal pattern with the highest counts in the early evening.'
- Summary:
  1) There is a robust correlation for tree pollen measurements between the APS-300 and current gold standard;
  2) High precision for tree pollen measurements between the different APS-300 devices;
  3) Pollen levels and major species vary spatially at less than 10 km scale; and
  4) Current results on grass/weed pollen from the sensor need improvement
- Next steps are to further investigate spatial contrasts and diurnal variability and to expand the monitoring network.

7. Using NAB Data to Understand and Forecast Pollen for Health (Fiona Lo)

* The impact of seasonal allergies caused by pollen is underestimated. Up to 30% of U.S. population has allergic rhinitis resulting in indirect costs such as lower productivity, poor school performance and poor sleep.
- Daily pollen concentration data are available from the NAB from 2003 through 2020. However, the NAB only collects at 65 stations and ID's 38 pollen types.
- Challenges with NAB data include: limited spatial coverage, many stations with missing days, confusion over whether zero pollen concentrations or missing data, standardization (Hirst versus rotorod, collection height, number of days/week sampling), incomplete metadata, and difficulty obtaining data.
- Solutions to limited spatiotemporal coverage: Google search for "pollen" can approximate early season pollen concentrations but this is dependent on internet search volume and magnitude of pollen peak, and use of pollen model to fill in for missing data.
- CDC Climate and Health Group has determined that moderate levels of pollen concentrations (20-50 grains/m3) increased doctor's visits and allergy med prescriptions. Based on this start date of pollen season is defined as the day that sum of daily pollen concentration reaches 50 grains/m3.
- An analysis of data for Oak pollen shows that start dates are earlier at lower latitudes and last longer. The relationship is similar for other trees species and grass pollens.
- Meteorological conditions affect pollen concentrations. Temperatures above 22 degrees Celsius, sunny conditions, low humidity and gusty winds result in extremely high pollen concentrations (944 grains/m3).
- A pollen model needs to take into consideration temperature, wind, solar radiation, humidity and precipitation. The photoperiod, solar radiation, temperature and water (precipitation and humidity) are factors that affect plant development.

- A pollen model can provide useful data for allergy sufferers such as a 7-day forecast of start of allergy season for allergy medication use as well 1 to 3 day forecast of high pollen concentrations for avoidance of these conditions.
- A model can also fill in for missing weekends.
- In summary:
  1) NAB data are used to understand pollen for health reasons such as when, where, how much and what type.
  2) Pollen calendars are developed. Start dates depend on latitude and season duration is correlated with start dates.
  3) Pollen Model is based on meteorology and environmental factors. Model can be used to forecast for start of pollen season as well as for high pollen days.
  4) Model can also fill in for missing days and expand the spatial coverage to areas with no ongoing pollen observations.

8. Modeling Pollen Emissions for the Present-day and the Future (Allison Steiner)

- The atmosphere is the medium for anemophilous (wind-driven) pollen;
- Pollen is the driver for seasonal allergies that affect approximately 36 million people in the U.S.;
- Since pollen grains can influence cloud properties, they can potentially influence climate.
- Pollen data are very sparse.
- Pollen can be grouped by plant functional type for analyses.
- Need to better understand the pollen situation. How does it contribute as an aerosol for example. So need to develop a model.
- Model parameters: Pollen emissions potential (E) = Production (P) x Area x phenology. Productions factors are temperature dependent.
- Can produce animated maps with model that depict gridded daily pollen emissions at a 25km resolution for deciduous and evergreen trees, grasses and more specifically, ragweed. Can see a seasonal cycle this way.
- This model can also then be used with future climate projections since temperature drives phenology and production changes. Can predict how pollen seasons and production magnitude change with climate change.
- Simulation showed that almost all types of vegetation will have longer seasonal durations as start of pollen season shifted to 10-40 days earlier for trees and 5-15 days later for ragweed.
- Can also predict percent change at end-of-century of maximum daily pollen emissions compared to historical.
- Annual pollen emissions will increase by 15-40%.
- Pollen can rupture under moist conditions which cause emissions of fine particles that can contain the allergenic protein. So, pollen ruptures were built into the model.
- Pollen included in the WRF-CHEM modeling framework: Dynamic modeling of

atmospheric processes. Simulations in the southern great plains which has lots of thunderstorm activity causing rupture.

- Also modeling dry and wet deposition of pollen:
  1) Dry deposition: primary pollen is treated as coarse mode dry particle with standard deposition velocities plus sedimentation; ruptured pollen is treated in the accumulation mode with standard dry deposition velocities.
  2) Wet deposition: pollen removal by precipitation, large scale and convective. Evidence from Hughes et.al., 2020, identifies some compounds that are likely markers for pollen rupture.
  3) Currently, there is no way to evaluate the model.
- Conclusions and Future Work:
  1) Produce quantified pollen impacts due to temperature and precipitation changes for the end of the century;
  2) Next steps are to continue working with NOAA Air Quality Forecasts to incorporate the emissions in the daily RAP-Chem air quality forecasts, and to improve the phenological processes and land use representation in the model.
  3) Challenges: sparse data! More observations are needed, especially non-urban.

9. Stakeholder Updates

- Due to lack of time, stakeholder updates were requested by email from the representatives of each group: CSTE, CDC, EPA, and CityDep.
- No updates received as of July 25, 2022.

10. Wrap-up and Adjourn

- Meeting adjourned by Andy Johnson.