NCAR
Earth System Laboratory

Atmospheric Chemistry Division Strategic Plan 2013-2018

Mission Statement

Our mission is to advance understanding and predictive capability of atmospheric composition and related processes, and to provide intellectual leadership and facility support to the wider community.

Contents

Introduction 1

Major Scientific Challenges for Atmospheric Chemistry 1

Air Quality Prediction Research 1

Interactions between Chemistry and the Climate/Weather Systems 3

Foundation Science 4

ACCORD and Remote Sensing Observations 4

Atmospheric Chemistry Modeling Across Scales 5

Integrating Models and Observations 8

Laboratory Process Studies 8

Data Assimitation 8

Field Campaigns 9

Partnerships 11

Appendix: List of Acronyms 12

Introduction

The National Center for Atmospheric Research (NCAR) is a Federally Funded Research and Development Center (FFRDC) devoted to service, research and education. The Atmospheric Chemistry Division (ACD) is part of the NCAR Earth System Laboratory (NESL), which focuses on the physical climate system, including weather, chemistry and climate. Research within ACD is aimed at quantifying and predicting the role of atmospheric chemistry in the Earth system. This includes providing the scientific expertise to develop observational and modeling capabilities to predict global-to-regional scale air quality and chemistry-climate interactions; to understand the underlying processes determining pollutant emissions, transport, chemical transformations and removal; and to inform the human and environmental health communities regarding present and future air quality issues. We also act as an intellectual resource by developing measurement capabilities and chemistry modeling tools and providing them to the wider atmospheric sciences community.

Major Scientific Challenges

Rapid growth in population and economic development are principal drivers of global change, including unprecedented changes in atmospheric composition. It is now recognized that human activities have perturbed the chemistry of the atmosphere at local, regional and global scales; these changes impact humans and ecosystems, and also affect climate variability and change through their radiative properties. Changes in atmospheric composition are a fundamental driver of the Earth system, and modeling activities at leading institutions are including atmospheric chemistry as part of coupled Earth system simulations. One goal of NESL is the development of a unified cross-scale weather-chemistry-climate prediction system.

While such unified models may be considered a longer-term goal, current and near-term atmospheric chemistry research goals can be classified broadly into two areas: Air Quality Prediction and Chemistry-Climate Interactions. Air Quality refers to near-surface composition with direct impacts on humans and ecosystems, often focused at regional scales (and studied via in situ observations and high resolution regional-scale models). Chemistry-climate interactions refer to variations in chemically active species (such as methane, ozone and aerosols) and their interactions with clouds and radiation to force climate change, especially on decadal and shorter time scales. These forcing agents differ from CO2 as their formation and/or removal occur through chemical reactions in the atmosphere. Understanding atmospheric chemistry at local to global scales requires fundamental research aimed at quantifying chemical processes and the links with the physical climate system (weather and climate), and this typically occurs through a synergistic combination of observations and modeling.

Air Quality Prediction Research

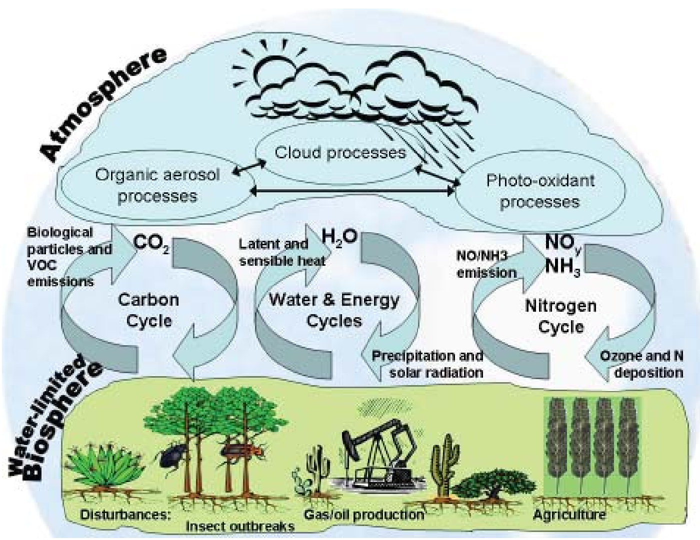
Poor air quality (AQ) is the source of significant human premature mortality and ecosystem damage, and thus is an issue of major societal concern on a global scale. In the United States alone, early mortalities due to exposure to air pollutants (mostly particulate matter, PM) are thought to exceed 100,000 per year, with health care costs exceeding $10 billion per year for related morbidities, while crop damage (primarily due to ozone exposure) is estimated to exceed $1 billion per year. Although it is evident that air quality in major U.S. cities has improved dramatically over the last few decades, exceedances of ozone and PM standards are still commonplace. These exceedances are likely to increase as national standards are lowered and global background ozone levels rise. AQ problems are even more severe in the developing world, due to increasing populations, trends toward urbanization, and generally lagging technological capacity and emission-control standards. Over 3 million people died prematurely from outdoor air pollution in 2010, mostly in Asia. Of particular concern is that air pollution is one of the fastest growing health risks in the world, with a 300% increase in premature deaths from 1990 to 2010.

The quantification and prediction of air quality (and more generally, atmospheric composition) is thus of critical societal importance. This must include an understanding not only of AQ-related issues in urban areas, but also an understanding of the impacts of urban emissions on regional to inter-continental scales. NESL/ACD will continue its studies of air quality and atmospheric composition, using an integrated approach that includes laboratory-based process studies, in situ and remote observations, modeling and data assimilation. The goal of the research is to increase predictive capability for present and future AQ, and thus provide a strong scientific foundation upon which mitigation and adaptation strategies and policy decisions can be based. A particular target is the development of a high resolution coupled AQ – meteorological forecasting capability.

Air quality research in NESL/ACD in the coming years will focus on the following topics:

Understanding, observing, modeling and forecasting air quality and composition in the developed and developing world

High-resolution WRF-Chem simulations over North America and Asia are being used to understand the driving forces of present day AQ in developed and developing countries, and to project changes over the next decades in response to possible trajectories in industrialization and urbanization as well as climate and weather. Exceptionally large changes in composition and aerosols have occurred over Asia, and simulation of this region is a frontier for current modeling capabilities. The high resolution (~4 km) WRF-Chem simulations explore the feedbacks between the physical and the chemical atmosphere and are also used to downscale global climate simulations with chemistry from the CAM-Chem model. The availability of long-term surface and satellite derived trace gas and aerosol concentrations provides data for constraining model simulations and understanding causes of past and potential future changes.



Understanding the interactions between natural and anthropogenic emissions

There is growing evidence that anthropogenic pollution can enhance the production of ozone and secondary organic aerosol from natural sources, leading to degraded AQ and a potentially strong impact on climate. This involves a coupling of the biological, chemical and physical components of the earth system requiring trans-disciplinary investigations. The processes involved are complex with compensating effects so that even the sign of the response to changes in emissions is difficult to quantify. Ongoing research focuses on investigating atmospheric, ecological and hydrological processes and their interactions, and surface fluxes of energy, aerosols, CO2, water, and organic and nitrogen compounds, followed by efforts to improve their representation in earth system models.

Extreme events: Heat waves and wildfires

Much of the human and ecosystem impacts of poor AQ occur during extreme events, such as heat waves and wildfires. The occurrence of heat waves has increased across the globe in recent years. These meteorological events are in turn linked to accumulation of pollutants from anthropogenic sources, stronger emissions from wildfires and biogenic sources, and enhanced photochemical production. These episodes provide extreme tests for simulating atmospheric photochemistry and transport within the boundary layer. Ongoing work is focused on the study of heatwaves in the United States (e.g. summers of 2006 and 2012), investigating the impacts of fire emissions on air quality and atmospheric composition, and their regional radiation impacts using online models such as WRF-Chem.

Interactions between Chemistry and the Climate/ Weather System

Earth's climate is changing as the result of human activity. While increased levels of atmospheric CO2 are the major forcing agent, climate is also impacted by changes in other trace species, including methane, nitrous oxide, halocarbons, tropospheric and stratospheric ozone, and aerosols, whose lifetimes and distributions (and thus climatic impacts) are all controlled by chemistry. Although present-day aerosols probably act to cool the atmosphere on the global scale, there is considerable uncertainty regarding their overall climatic impact (including the warming effects of black carbon). Roughly half of this aerosol loading is believed to be formed from organic species, yet the chemistry and physics that lead to their production, growth and loss is poorly understood, as are their optical and hygroscopic properties. The biosphere acts as a major source of atmospheric trace gases, particularly reactive volatile organic compounds (VOCs), and the nature and strength of these emissions are evolving as the result of climate and land-use change. The composition of the stratosphere is also changing as the result of human activity – levels of greenhouse gases continue to increase, while stratospheric ozone recovers following the Montreal Protocol - and these changes influence climate in the lower atmosphere.

Research in the near future will focus on the following topics:

Ozone and oxidants

Accurate predictions of the future evolution of reactive greenhouse gases (CH4, ozone, halocarbons) and secondary aerosols (sulfate, nitrate, organics) rely on our ability to understand present-day behavior and forecast long-term changes of the oxidizing capacity of the atmosphere. This requires accurate measurements and modeling of the key reactive nitrogen (NOx) species and volatile organic compounds (VOCs) that fuel tropospheric chemical cycles, in addition to quantifying intermediate species (such as peroxides and formaldehyde) and the main tropospheric oxidizing agent, OH. Measurement-model comparisons should span all temporal and spatial scales, e.g. at the local level via direct measurement of species with constrained process models, and globally by use of satellite-derived measurements.

Production, properties and lifetimes of atmospheric aerosols

Anthropogenic aerosols contribute the largest uncertainty in current estimates of radiative forcing, both directly and through interactions with cloud microphysics. Future improvements in air quality may unmask additional warming, leading to an air quality penalty to climate. A detailed understanding and model representation of the sources, growth, transformations and ultimate fate of atmospheric aerosols is central to both AQ and climate science topics. Accurate model parameterizations are required to describe aerosol compounds that are highly oxidized (and so likely both toxic and hygroscopic), and the ones that are optically active. Organic aerosols fall in this category, and observations show that they are ubiquitous and abundant. Detailed evaluation and modeling of measurements made in the lab (kinetic, mechanistic, smog chambers) and in field campaigns will be used to improve understanding and representation of aerosols in regional and global models.

Upper Troposphere – Lower Stratosphere (UTLS) processes, including convective transport and stratosphere-troposphere exchange

The UTLS is a region of complex dynamical, chemical and radiative characteristics, with strong gradients in trace species and enhanced climate sensitivity to changes in water vapor, ozone, aerosols and clouds. Transport and exchange associated with deep convection, tropospheric weather systems and the large-scale global circulation impact the distribution of these species. Current work focuses on combining chemical and meteorological measurements from aircraft and satellites with regional and global modeling to improve understanding of UTLS circulation and transport pathways, and in turn improving representation of these climate relevant processes in global models.

The role of the middle atmosphere in climate

Observations and model simulations have demonstrated that past and projected changes in stratospheric composition affect tropospheric climate.

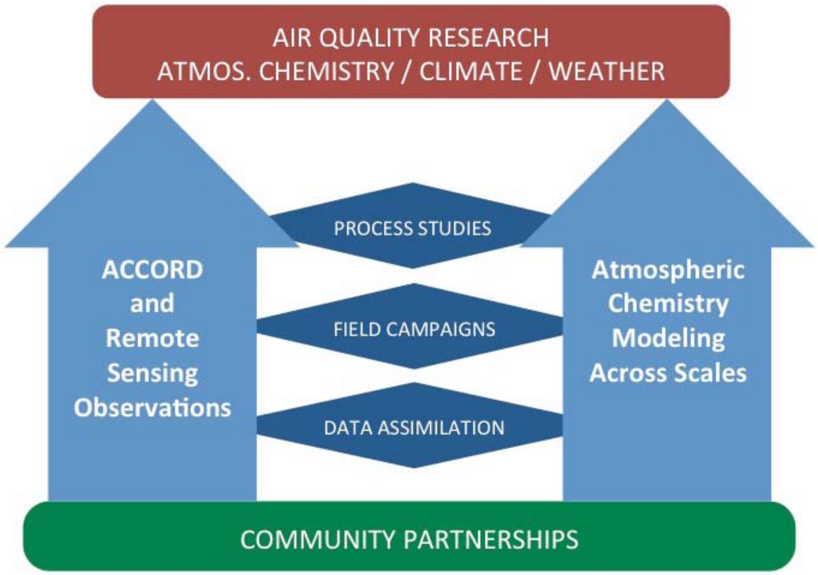
For example, the Southern Hemisphere climate system (precipitation, temperature, surface wind stress, sea ice extent, etc.) has been modified by evolution of the Antarctic ozone hole. The future response of the climate system to the recovery of stratospheric ozone combined with increasing greenhouse gases is a complex problem, requiring modeling tools with fully resolved stratospheric circulation and chemistry (WACCM). Uncertainties further exist in understanding microphysical processes and aerosol behavior, and improvements in this area require the use of detailed microphysical models like CARMA. These tools will also allow quantification of the whole atmosphere response to natural variability such as volcanic eruptions, solar and energetic particle forcing, as well as changes resulting from proposed geoengineering activities.

Foundational Science

The bases for addressing the broad scientific challenges listed above are foundational research activities of observations and modeling, and their synthesis. Atmospheric chemistry research is an observationally-driven enterprise, and ACD has substantial heritage with in situ and remote sensing observations of atmospheric composition. The scientific activities of NESL/ACD involve the integration of observations with atmospheric chemistry modeling across scales (including process, regional and global models), with a focus on understanding and modeling fundamental processes. The regional and global chemistry modeling activities are closely linked with the WRF (weather) and CESM (climate) modeling foci within NESL.

A major new observational activity is the Atmospheric Chemistry Center for Observational Research and Data (ACCORD), which will provide focus and consolidation of in situ measurement capabilities, in collaboration with the NCAR Earth Observing Laboratory (EOL) and the wider atmospheric chemistry research community (www2.acd.ucar.edu/accord). ACCORD will facilitate development of community-based observational capability, including community-requestable instruments and field campaign design and coordination. The ACCORD leadership team will develop a strategic plan that will complement the ACD and NESL strategic plans.

The foundational science within ACD is built upon ACCORD, Remote Sensing Observations and Atmospheric Chemistry Modeling, with key integration activities based on process studies, field campaigns and chemical data assimilation. These activities are founded on strong community partnerships, in the form of collaborative research, active visitor programs, and education and outreach accomplished as an integral part of science activities.



Schematic of key activities in ACD: Pillars of observations and modeling

ACCORD and Remote Sensing Observations

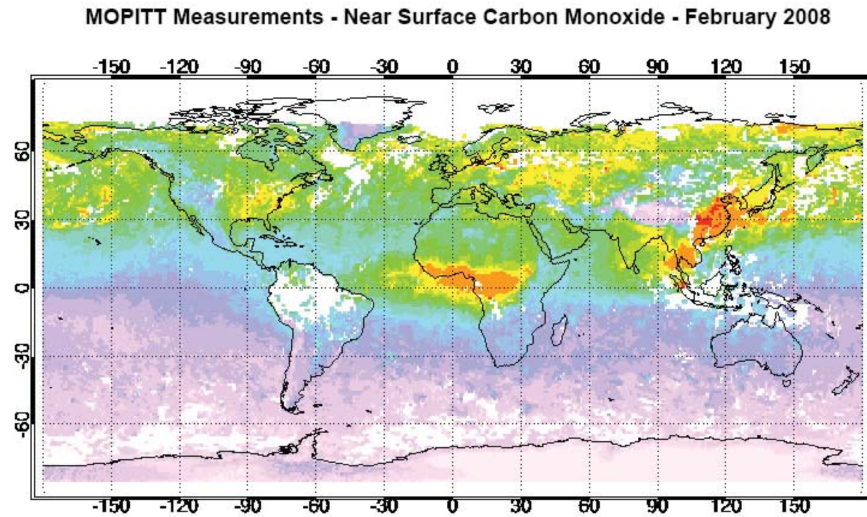
Develop, maintain and utilize world-class atmospheric composition observational capabilities, including in situ observations, laboratory facilities and atmospheric remote sensing.

Develop ACCORD and integrate across the breadth of ACD activities. Maintain and develop pool of community-requestable instruments in collaboration with EOL

The implementation of ACCORD will be the major focus of ACD observational science for FY13 and FY14. A scientific steering committee will be appointed to implement ACCORD by forming working groups that will identify scientific challenges associated with in situ atmospheric chemistry observations and to guide the prioritization of resources. Four ACCORD working groups will focus on: 1) the identification of emerging scientific topics and associated research approaches, 2) development and maintenance of community requestable instruments for core measurements in partnership with NCAR/EOL, 3) instrument development and characterization, and 4) data management and integration. ACCORD will provide an intellectual meeting ground for the research community to discuss and prioritize scientific problems linked to atmospheric chemistry, and it will serve to develop community-wide capabilities to address those problems.

Ground-based and satellite remote sensing of atmospheric composition

ACD will continue to lead the development and utilization of improved carbon monoxide (CO) retrieval algorithms for MOPITT (Measurements of Pollution In The Troposphere), onboard the Terra satellite. MOPITT currently provides the longest running global CO record, with sensitivity to both surface and free troposphere concentrations. Ground-based FTIR observations are made continuously at Thule, Greenland, and Mauna Loa, Hawaii, in support of the Network for the Detection of Atmospheric Composition Change (NDACC). Atmospheric composition ground-based and satellite remote sensing observations (from MOPITT, NDACC, and other satellite missions and ground-based observations) will be utilized to provide the regional to global complement to in-situ measurement activities within ACCORD. Current expertise on satellite composition, cloud and aerosol measurements from the NASA A-Train (along with future missions including SAGE III, OCO-2 and TEMPO) will be exploited to evaluate and improve global model simulations.



MOPITT is an instrument flying on NASA's EOS Terra spacecraft, measuring tropospheric carbon monoxide (CO) on the global scale. MOPITT measurements enable scientists to analyze the distribution, transport, sources and sinks of CO, a trace gas produced by methane oxidation, fossil fuel consumption and biomass burning. MOPITT has been operational since March 2000.

Atmospheric Chemistry Modeling Across Scales

Build, critically evaluate and apply process, regional-scale and global-scale models that address the above science questions. Quantify and improve couplings between atmospheric chemistry and different components of the Earth system (water cycle, biosphere, cryosphere). Plan for and develop next generation modeling tools.

Develop the next-generation atmospheric chemistry model

Next generation climate and weather global models (e.g., MPAS) will have variable grid spacing to achieve high spatial resolution over selected regions without the need of a global and a regional model. Scientists in ACD will lead the development of an atmospheric chemistry component suitable for the incorporation of chemistry and related physical processes (e.g. wet deposition and production of NOx by lightning) into such models. It will allow use of simpler chemical mechanisms for climate timescale simulations or more complex mechanisms for process studies. Lessons learned from b.-d. below, ACCORD, and modeling support of observational campaigns will be used to inform the development of such next-generation models. This activity will require close collaboration with MMM and CGD.

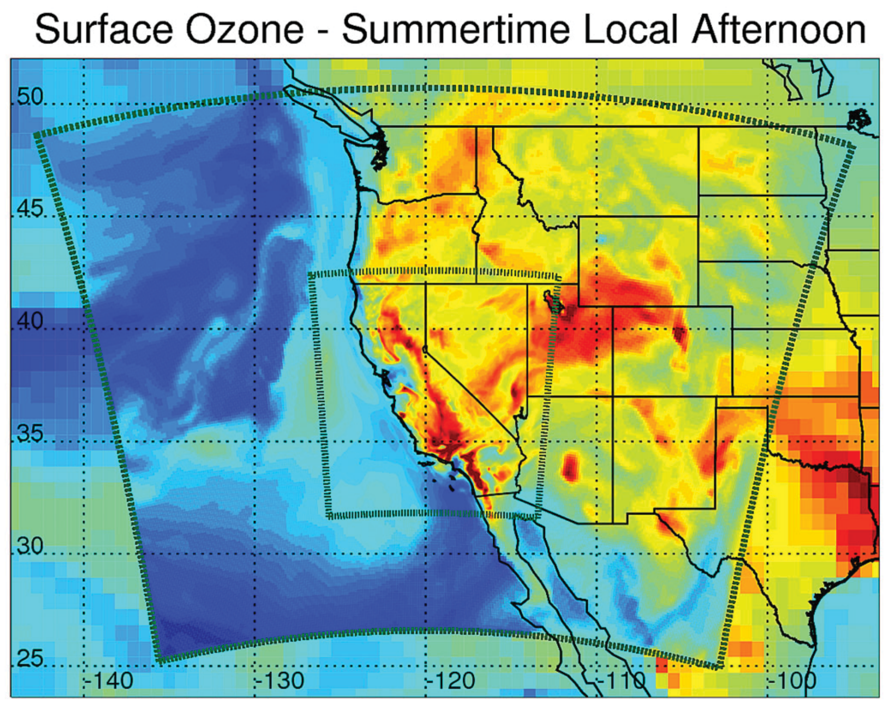
Maintain and improve chemistry modeling at regional and global scales in current NCAR models

WACCM

WACCM is now fully integrated into CESM and allows for representation of chemistry climate interactions that include coupling between the upper and lower atmospheric and the ocean and cryosphere. Development will aim to improve the circulation of the middle atmosphere, principally by revising the gravity wave parameterization, such that a QBO is generated internally, and alleviating the existing cold-bias in southern hemisphere winter and spring. The representation of volcanic aerosols will also be improved. There are now extensive satellite measurements of the energetic system of the middle atmosphere that will be used to evaluate the relevant chemical and physical processes, and where needed, improve the simulations. While WACCM will continue to be run at moderate resolution for climate studies, experiments at much higher resolution will be carried out to gain experience with such runs and to explore what resolution is needed before gravity wave parameterization becomes unnecessary, at least in principle.

CAM-Chem

Beyond continuous improvements in our representation of atmospheric chemistry, the present state of secondary organic aerosol representation in CESM requires significant improvement. This will be tackled through updates to the chemical mechanism and implementation of the volatility based-set approach. This is critical for the understanding of the role of natural (i.e. biogenic) and anthropogenic aerosols on the direct and indirect radiative forcing of climate. To further advance the understanding of the coupling between biogenic emissions, composition and climate, CESM will need to be expanded to include more comprehensive emissions of ozone and aerosol precursors, over both land and ocean. In particular, we will use the interactive fire module newly developed in CLM to provide climate-dependent biomass burning emissions. CAM-Chem will be used to address science questions related to climate impacts of short-lived climate forcers (anthropogenic aerosol, ozone and methane), the potential impacts of engineered aerosols, and cloud-aerosol interactions.



Cross-scale modeling: Summertime surface ozone (ppbV) from a global MOZART-4 simulation at T170 spatial resolution (~70 km), which is used for lateral boundary conditions for a nested regional WRF-Chem domain (12 x 12 km2 and 4 x 4 km2).

WRF-Chem

ACD scientists will continue to provide community support and to contribute to WRF-Chem model development for air quality and regional climate applications. Model improvements are connected to the field programs led by ACD and also those in which ACD scientists participate. Current foci are:

1. A more accurate representation of the formation (in both gas and aqueous phases) and removal processes of organic aerosols is being developed using observations from BEACHON-RoMBAS and other field measurements and from detailed process modeling (GECKO-A) in forested and urban environments.

2. Parameterizations of the wet scavenging and convective transport of trace gases and aerosols, and of NOx production in lightning, will be evaluated and improved using observations from the DC3 field campaign.

3. Chemistry mechanisms included in WRF-Chem for urban plumes (FRAPPÉ), rural regions (BEACHON and NOMADSS), the urban-rural interface (GAMBAI), and the upper troposphere (DC3) will be improved based on observations from these past and upcoming field campaigns.

4. While MEGAN in the WRF-Chem modeling system will continue to be maintained, the MEGAN model coupled with the Community Land Model (CLM) will be incorporated into WRF-Chem to better address the chemistry for biogenic-rich regions and chemistry-climate studies. This will allow for consistency between global and regional chemistry modeling.

5. The gas-phase chemistry and the speciation of VOC emissions from MEGAN and anthropogenic inventories will also be assessed with new data and updated in the WRF-Chem model.

Maintain and improve Emissions and Process models

Shortcomings in atmospheric chemistry models are often linked to uncertainties in emissions (anthropogenic, biogenic, soil, ocean, volcanic, and fires) and shortcomings in our understanding of chemical transformation and removal processes. ACD is leading the development and application of emissions and process models that are used in NESL/ACD, and that are also widely used in the outside research community.

MEGAN (Model of Emissions of Gases and Aerosols from Nature)

MEGAN is a global biogenic emissions model which is coupled to the CESM land model and to the WRF-Chem model. Major enhancements planned for the next generation of MEGAN include 1) addition of biological particles (e.g., pollen, spores, bacteria) and nitrogen gases, 2) development of a modeling scheme that is better integrated with NCAR land surface models (e.g., CLM), 3) use of aircraft flux measurements and other data to improve models parameterizations, and 4) implementation of an initial approach to quantify the emission response to stress including extreme events.

FINN (The Fire INventory from NCAR)

FINN provides daily global fire emissions estimates at a resolution of approximately 1 km, driven by rapid-response satellite observations. Future improvements include implementation of updated and more accurate land cover and fuels data, updated emission factors reflecting advances in laboratory and field measurements, and speciation to additional chemical mechanisms.

GECKO-A (Generator of Explicit Chemistry and Kinetics of Organics–Atmosphere)

The GECKO-A model provides comprehensive representation of the atmospheric photo-degradation of VOCs, and their thermodynamic properties that determine gas/particle/cloud partitioning. The GECKO-A model will be used to examine SOA formation from anthropogenic, biogenic, and mixed VOCs. Updates to GECKO-A will be based on emerging kinetic, thermodynamic and spectroscopic lab measurements and theoretically-derived data. GECKO-A will further be used to evaluate simplified parameterizations for predicting reasonable amounts of SOA in climate models.

Testing models: Understanding the past and predicting future AQ and composition

The evaluation of global and regional chemistry-climate models will follow our existing approach of extensive comparison to available ground-based, aircraft and satellite observations. These activities include comparison of models with past observations, plus extensive model-model intercomparisons with the wider community. A future focus will be participation in the IGAC/SPARC Chemistry-Climate Model Initiative (CCMI; http://www.pa.op.dlr.de/CCMI/) intercomparison projects. These include simulations of hindcast (1960-present) and future (1960-2100) conditions that can be used for studying chemistry-climate interactions and regional air quality.

Integrating Models and Observations

An overarching goal of ACD is the effective integration of observational and modeling expertise, leading to iterative improvements in both areas. For example, the ability to confront models with highly specific observations and focus observational studies using model predictions leverages both capabilities. Interactions among observational and modeling specialists lead to more robust models, more insightful measurements, and effective leadership in the Atmospheric Chemistry community. Specific activities that are tied with integrating observations and models include:

Laboratory Process Studies

The composition of the atmosphere is determined by a set of processes, including those that govern the emissions of trace species into the atmosphere, chemical transformation (in the gas- and condensed-phase), and depositional removal. Under the ACCORD umbrella, and with substantial community involvement, NESL/ACD operates three laboratory facilities that examine these processes, including an environmental chamber for study of gas-phase chemical reactions, an aerosol chamber for the study of particle formation and growth, and a controlled environment plant growth facility for characterizing biogenic emissions at the leaf/plant level. The results of these laboratory-based process studies are used to develop process-level models, such as the MEGAN emissions model and the GECKO-A chemical mechanism, and also parameterizations for community models such as CLM, WRF-Chem and CAM-Chem.

Specific short-term science activities include:

1. Conduct studies of the gas-phase oxidation mechanisms for oxygenated VOC, with a particular focus on reactions that control HOx radical budgets. Also conduct studies of the reaction of OH and NO3 with biogenic VOCs, with a particular goal of connecting these results with those related to SOA production.

2. Perform chamber studies of aerosol formation from the oxidation of biogenic VOCs, with the goal of developing a semi-empirical model for aerosol growth rates as a function of temperature, relative humidity, and gas-phase precursor (VOC and oxidant) concentrations.

3. Apply novel techniques (e.g. substrate pools, enzyme activity, electron transport rates, carbon isotope labeling) to investigate BVOC emissions including the long-term effects of changing growth temperature, light intensity and soil moisture on these emissions.

Data Assimilation

The incorporation of observations into models through data assimilation techniques can lead to improved forecasts, as well as identifying deficiencies in the forward model representations, including emissions, chemistry and transport. Chemical data assimilation is a key focus of the ACRESP group. Current goals include:

- Develop improved chemical data assimilation schemes for current satellite, field campaign and surface monitoring products. The use of the EnKF DART facility within CAM-Chem and WRF-Chem leverages expertise in other parts of NCAR and promotes collaboration.

- Use data assimilation to identify and quantify the strengths and weaknesses of current measurement and model approaches for understanding the drivers of AQ prediction. The EnKF approach provides information on the evolving covariance between chemical and meteorological parameters. The benefit of co-assimilating multiple measurements for constraining pollutant chemistry and improving model parameterizations informs recommendations for future improvements in AQ predictive capability.

- Quantify the measurement capabilities of future instruments and observing strategies through Observation System Simulation Experiments (OSSEs). NESL/ACD leads the community in the application of these techniques for the definition of future atmospheric composition satellite missions.

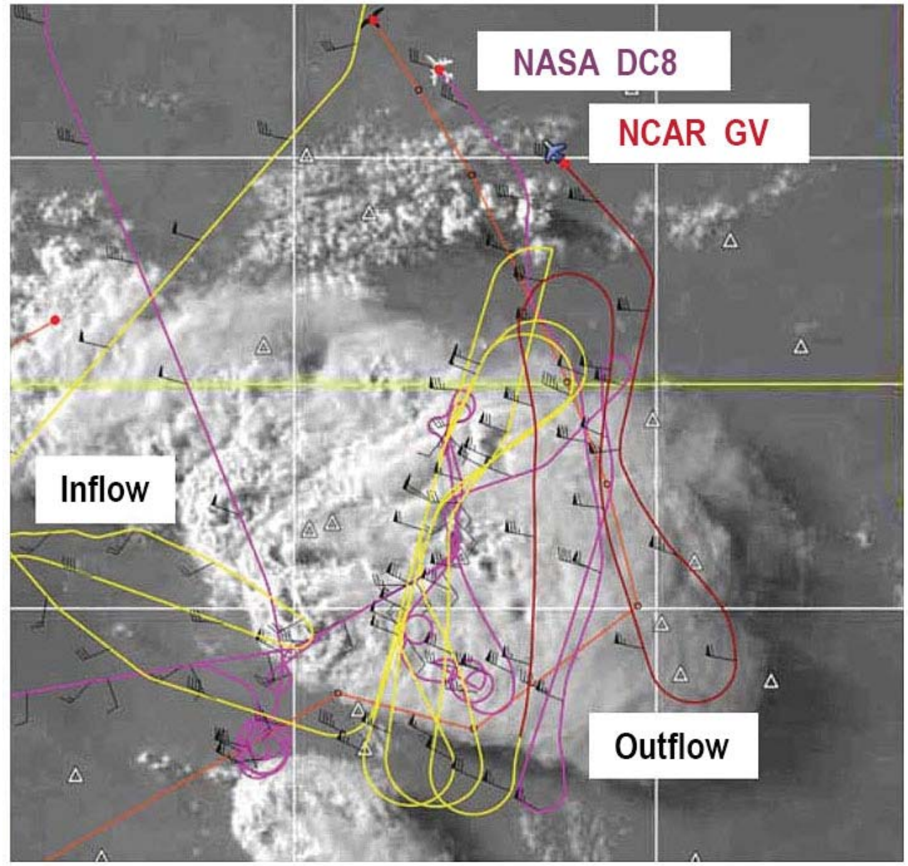
- Develop an air quality (chemical weather) modeling system for the Colorado Front Range that builds on the BEACHON and wildfire-AQ studies already being conducted and delivers a mature system for the FRAPPÉ field campaign.

Field Campaigns

Integrated regional field experiments are a key element of ACD's research activities, providing opportunities to quantify key atmospheric chemistry processes, such as emission fluxes, and chemical evolution in pollution transport and convective systems. ACD scientists regularly lead small and large field studies, and they also participate in community field experiments led by other organizations (NASA, NOAA, EPA, universities). Analysis of recent experiments will continue over the next few years, and several experiments are scheduled or proposed.

Emphasize analysis of past observations, especially from DC3

The Deep Convective Clouds and Chemistry (DC3) project, which conducted a field study in May and June 2012, is investigating the impact of dynamical, physical, and lightning processes associated with midlatitude thunderstorms on upper tropospheric (UT) composition and chemistry. Analysis of the field data by ACD scientists includes examination of 1) the transport and scavenging of trace gases and aerosols by different types of storms, 2) impacts of storms on upper tropospheric NOx both near storms and on the regional scale, 3) convective injection into the stratosphere, 4) dynamical storm impacts on UT composition, and 5) ozone production potential downwind of storms. Because biomass burning was prevalent during the time period of the campaign, characterizing the chemistry and composition of specific biomass burning plumes is also being addressed.



Flight patterns for two aircraft involved in the DC3 field campaign over a convective storm in Oklahoma on May 29, 2012

Future and proposed field campaigns

1. NOMADSS (Nitrogen, Oxidants, Mercury and Aerosol Distributions, Sources and Sinks; June-July 2013):

   NOMADSS is a community field study sponsored by NSF, in partnership with NOAA and EPA, focused on summertime atmospheric chemistry in the southeastern US. The study will integrate regional modeling, satellite observations, laboratory studies plus ground and airborne (NCAR/NSF C-130 and NOAA P3) measurements. This experiment will explore the sources and processes controlling the fate of BVOC in polluted environments, with goals to: 1) directly quantify biogenic VOC emissions relevant for regional models and use boundary layer flux measurements to estimate regional oxidizing capacity, 2) characterize the biological, physical and chemical processes controlling chemical fluxes, and 3) use observations and models to investigate the interactions between biogenic emissions and anthropogenic pollution.

2. CONTRAST – (Convective Transport of Active Species in the Tropics; January-February 2014

   CONTRAST is a joint university-NCAR field experiment planned to investigate the role of tropical convection on chemical transport in the persistent convective environment of the western Pacific. Specific scientific objectives are 1) to characterize chemical composition and ozone photochemical budget, 2) to evaluate budgets of bromine and iodine species in the UTLS, 3) to investigate transport pathways, and 4) to integrate observations with chemistry-climate models. The campaign involves deployment of the NCAR/NSF GV research aircraft, to be operated from Guam, and includes collaboration with the NASA ATTREX (Global Hawk) and CAST (British BAE146) experiments to sample the relevant suite of chemical species from the marine boundary layer to the lower stratosphere.

3. DISCOVER-AQ FRAPPÉ (Front Range Air Pollution and Photochemistry Éxperiment, http://www2.acd.ucar.edu/frappe; summer 2014):

   FRAPPÉ is a proposed NCAR/NSF C-130 and ground-based campaign to determine the factors controlling AQ and surface ozone in the Colorado Northern Front Range Metro Area. The campaign will complement the fourth NASA-led DISCOVER-AQ mission, which is an ongoing NASA effort aimed at improving satellite capability to interpret AQ conditions in US urban areas. FRAPPÉ will also be closely linked to a proposed study (FRONT-PORCH) of the meteorological and hydrological processes influencing the Colorado Front Range. These combined missions provide an opportunity to study and characterize local AQ and links to meteorological structure at a level of detail not previously possible.

Scientists from ACD, Universities and NASA track thunderstorm formation and aircraft location in the Operations Center during DC3 .

4. GAMBAI (Gases and Aerosols in Megacity--Biosphere--Atmosphere Interactions; ongoing with intensive campaign in May-June 2016, or later)

   The GAMBAI project focuses on the interaction of anthropogenic and natural emissions in Asia. GAMBAI has begun by providing guidance and measurement expertise to scientists in South Korea to measure biogenic emissions fluxes and ambient concentrations from a tower outside Seoul. An aircraft experiment is being designed to study pollution outflow from China, interaction of anthropogenic emissions with forested regions of Korea, and chemical evolution of haze and pollution over Korea, Taiwan and Japan (in collaboration with Asian scientists and carried out jointly with NASA, tentatively scheduled for May-June, 2016).

Partnerships

Partnerships with the wider science community are at the heart of the NCAR mission, and are an important component of all research conducted within ACD. Strong collaborations within NCAR include: 1) partnerships with EOL on providing atmospheric chemistry measurement capabilities, 2) ongoing collaborations within NESL on global and regional modeling, including CESM, WRF and MPAS modeling systems, 3) collaborations with HAO and CGD on middle and upper atmosphere coupling to the climate system and development of WACCM, and 4) collaborations with RAL on ecohydrological research and the interactions between physical and social drivers of air quality impacts.

While NESL/ACD has a strong history of collaborations with university scientists, this activity will strengthen with the implementation of ACCORD in the coming years. Specifically, the ACCORD SSC will help determine future community measurement and field experiment priorities. An annual ACCORD workshop is anticipated which will facilitate development and growth of effective partnerships, including opportunities to entrain students and young scientists into observational atmospheric chemistry research.

ACD will continue close collaborations with US agency partners. Large field programs (DC3, and planned NOMADSS, FRAPPÉ, CONTRAST and GAMBAI) occur as collaborative efforts with university, NASA, NOAA and other federal agency scientists. Modeling partnerships include those with DOE scientists on evaluating and improving simulations of tropospheric aerosols, tested with observations from the field programs. NASA, NOAA, EPA and DOE are also represented ex officio on the ACCORD steering committee, so that future community priorities and plans will be determined in a coordinated and collaborative manner. The ground-based and satellite remote sensing activities in ACD are largely supported by NASA, and strong partnerships with observational networks (NDACC) and satellite development at other institutions are integral parts of those activities. ACD will continue significant international collaborations, including leadership roles in IGAC, SPARC and iLEAPS. These are the major international organizations connecting atmospheric chemistry research to air quality, human impact on the global environment, and climate change processes. New international partnerships will be important in planned Asian air quality studies.

Connecting the atmospheric chemistry research with social impacts is a frontier that ACD seeks to strengthen in coming years. Current efforts to build collaborations with experts in areas such as socio-economic vulnerability and epidemiology focus on the health impacts of poor air quality. Additional collaborations with economists and hydrologists are exploring the impact of air pollution on agriculture and the water cycle. Partnerships with the Colorado Department of Public Health and Environment (CDPHE) are focused on air quality and health outcomes that resulted from the 2012 Colorado wildfires, with planned collaborations on the FRAPPÉ experiment in 2014.

Acronymns

ACD – Atmospheric Chemistry Division
AQ – Air Quality
ACCORD – Atmospheric Chemistry Center for Observational Research and Data
A-Train – A convoy of satellites that crosses the equator each day around 1:30pm; the “A” stands for afternoon
ATTREX – Airborne Tropical Tropopauce Experiment
BAE-146 – regional airliner manufactured in the United Kingdom
BEACHON – Bio-hydro-atmosphere interactions of Energy, Aerosols, Carbon, H2O, Organics and Nitrogen
BVOC – Biogenic Volatile Organic Compound
C-130 – four-engine turboprop
CAM-Chem – Community Atmosphere Model with Chemistry
CARMA – Community Aerosol and Radiation Model for Atmospheres
CAST – Coordinated Airborne Studies in the Tropics
CCMI – Chemistry-Climate Model Initiative
CD-PHE – Colorado Department of Public Health and Environment
CESM – Community Earth System Model
CGD – Climate and Global Dynamics Division
CH4 – Methane
CLM – Community Land Model
CONTRAST – Convective Transport of Active Species in the Tropics
DART – Data Assimilation Research Testbed
DC3 – Deep Convective Clouds and Chemistry field campaign
DISCOVER-AQ – Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality
DOE – Department of Energy
EnKF – Ensemble Kalman Filter
EPA – Environmental Protective Agency
EOL – Earth Observing Laboratory
FFRDC – Federally Funded Research and Development Center
FINN – The Fire INventory from NCAR
FRAPPÉ – Front Rance Air Pollution and Photochemistry Éxperiment
FRONT-PORCH – Front Range Observational Network Testbed - Precipitation Observations and Research on Convection and Hydrometeorology
FY – Fiscal Year
GAMBAI – Gases and Aerosols in Megacity–Biosphere–Atmosphere Interactions
GECKO-A – Generator of Explicit Chemistry and Kinetics of Organics – Atmosphere
GV - Gulfstream 5
HAO – High Altitude Observatory
IGAC – International Global Atmospheric Chemistry
iLEAPS – integrated Land Ecosystem - Atmosphere Process Study
MMM – Mesoscale and Microscale Meteorology Division
MOPITT – Measurements of Pollution in The Troposphere
MEGAN - Model of Emissions of Gases and Aerosols from Nature
MPAS – Model for Prediction Across Scales
NASA - National Aeronautics and Space Administration
NCAR - National Center for Atmospheric Research
NDACC – Network for the Detection of Atmospheric Composition Change
NESL - NCAR Earth System Laboratory
NOMADSS - Nitrogen, Oxidants, Mercury and Aerosol Distributions, Sources and Sinks
NOAA – National Oceanic and Atmospheric Administration
NOx – Generic term for mono-Nitrogen Oxide
NSF – National Science Foundation
OCO-2 – Orbiting Carbon Observatory 2
OSSE - Observation System Simulation Experiments
P-3 – NOAA’s Hurricane Hunter Aircraft
PM – Particulate Matter
QBO – Quasi-Biennial Oscillation
RAL – Research Applications Laboratory
RoMBAS - Rocky Mountain Biogenic Aerosol Study
SAGE III – Stratospheric Aerosol and Gas Experiment III
SOA – Secondary Organic Aerosol
SPARC – Stratospheric Processes and their Role in Climate
TEMPO - Tropospheric Emissions: Monitoring of Pollution
UTLS – Upper Troposphere Lower Stratosphere
VOC – Volatile Organic Compound
WACCM – Whole Atmosphere Community Climate Model
WRF – Weather Research and Forecasting Model
WRF-Chem – WRF Model with Chemistry