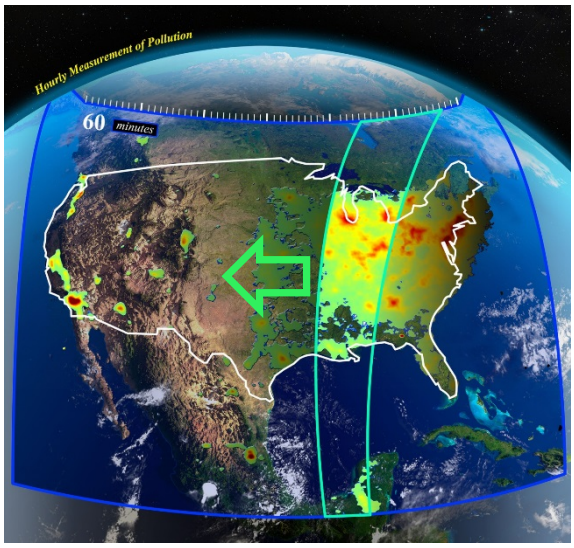
First TEMPO Applications Workshop

Meeting Summary

Shelby Center for Science and Technology
Sponsored by: NASA Applied Science Program
Hosted by: University of Alabama in Huntsville (UAH) / Earth Science System Center,
UAH Atmospheric Science Department, and
NASA/MSFC/Short-term Prediction Research and Transition (SPoRT) Center
July 12-13, 2016



TEMPO Field of Regard (FOR) over the greater North America (blue box). Scanning pattern of TEMPO spectrometer highlighted by green box and arrow indicating scan direction.

Workshop Purpose and Objectives

In July 2016, NASA held the First TEMPO Applications Workshop to identify the myriad of capabilities and applications of TEMPO, to recognize the needs of the end-user community, and to discuss the necessary next steps for preparation of the TEMPO launch. The TEMPO Applications Workshop focused on the following specific objectives:

- Provide a common ground for air-quality experts to converge toward a system that will realize the benefits of TEMPO as soon as it is launched and operational.
- Commence a conversation between air-quality forecasters, users, managers, and the TEMPO data/product-provider community to proceed toward being able to:
    - Identify key end users and end-user applications in the areas of air-quality modeling; planning and assessment; emissions; and health, agricultural, and environmental impacts to establish a feedback loop for

the TEMPO Science Team to understand and supply products to meet these end-user requirements.
    - Use current systems (space-borne, surface networks, model/synthetic calculations) to emulate future TEMPO capabilities.
    - Define expected TEMPO product suite to air-quality forecasters, users, and managers, and identify specific applications/operations for evaluations.
    - Transition TEMPO products to users.
- Define the key elements to successful transition of TEMPO products.

Fulfilling these specific objectives four to five years prior to the expected launch date of the instrument demonstrates the commitment of the TEMPO Science Team in paving the pathway for a very successful mission.

Workshop Organization

The organizing process of the First TEMPO Applications Workshop was facilitated through a broad representation from the applications and end-user community. Members of the organizing committee included:

Participants	**Affiliation**
Mike Newchurch (Lead)	University of Alabama in Huntsville / Department of Atmospheric Science
Kelly Chance	Smithsonian Astrophysical Observatory
Betsy Edwards	NASA Headquarters
John Haynes	NASA Headquarters
Barry Lefer	NASA Headquarters
Ronald Cohen	University of California, Berkley
Jay Al-Saadi	NASA Langley Research Center
Sue Estes	NASA / University of Alabama in Huntsville
Terry Keating	U.S. Environmental Protection Agency
Chris McLinden	Environment Canada
Jeff McQueen	NOAA / NWS / Environmental Modeling Center
Doreen Neil	NASA Langley Research Center
Brad Pierce	NOAA / NESDIS / Center for Satellite Applications and Research (STAR)
Brad Zavodsky	NASA Marshall Space Flight Center

A very comprehensive two-day agenda assembled by the organizing committee encompassed four different sessions on day one that focused on the following end-user communities: 1) air-quality forecasting, 2) planning and assessment, 3) emissions, and 4) health, agricultural, and environmental impacts. On day two of the workshop, organizers allotted time for breakout group discussions where workshop attendees provided input regarding their data needs and other concerns in each of these specific user communities. Informal networking breaks after each session allowed time for further discussion and

brainstorming among the attendees and program managers. The workshop agenda is provided in the appendix.

Workshop Attendees

The 156 registered attendees (80 in-person attendees; 76 participated via remote meeting capability) for the workshop underscored the significant spectrum of interest in the TEMPO mission and the very large number of potential end-users of the data. Workshop attendees included federal employees from NASA and NOAA, employees from national, regional, state, and local health and environmental departments, supporting contractors, members of the academic community from universities and cooperative institutes from across the United States, and scientists involved in the private sector. Hosting at the University of Alabama in Huntsville allowed for a number of graduate students from the university to participate, along with members of the NASA DEVLOP project team at Marshall Space Flight Center. The broad range of backgrounds and interests among the workshop attendees highlighted the potential use of TEMPO data for a broad range of applications.

Background

The Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument is a NASA mission that is currently on-schedule and on-budget for an expected launch date in 2020 or 2021. It was competitively selected in 2012 as NASA's first Earth Venture Instrument, and will be hosted on a commercial geostationary communications satellite to maintain a constant view of North America that will allow for a complete East to West scan over the Field of Regard (FOR) every hour during the day. For each geospatial scene in the FOR, the TEMPO grating spectrometer instrument will measure the solar backscattered radiance in the ultraviolet (290-490 nm) and visible (540-740 nm) with a spectral resolution and sampling of 0.6 and 0.2 nm, respectively, for retrieving aerosol and cloud parameters along with the major elements in tropospheric ozone (O_3) chemistry cycle consisting of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), formaldehyde (H_2CO), glyoxal ($C_2H_2O_2$), water vapor (H_2O), and UVB radiation. The TEMPO instrument will also have the unique capability to distinguish between boundary layer and free tropospheric and stratospheric O_3 due to its multi-spectral capabilities. Additionally, air-quality monitoring from TEMPO can be accomplished at sub-urban scales due to its high spatial resolution of 2.1 km in the north-south direction and 4.7 km in the east-west direction at the center of the FOR. Altogether, the high temporal, spectral, and spatial resolution of the TEMPO will provide unprecedented daylight observations from space for effectively monitoring the rapidly varying emissions and chemistry that governs our air-quality conditions. Our increasing knowledge of the air-quality effects on the environment, climate, and public health, highlight a need to deliver robust data products from TEMPO to the end-users for their specific applications. The standard and near-real-time data products planned for TEMPO will benefit from the heritage of products developed from the Global Ozone Monitoring Experiment (GOME) and Ozone Monitoring Instrument (OMI) measurements as these extensively validated, advanced retrieval algorithms will help accelerate the development of improved algorithms for TEMPO.

Workshop Summary

Day 1

The presenters in each of the four core sessions, 1) air-quality forecasting, 2) planning and assessment, 3) emissions, and 4) health, agricultural, and environmental impacts, focused on identifying the anticipated advancements from the unique TEMPO measurements in these science areas and the potential benefits to the specific end-user communities.

Air-Quality Forecasting

The presenters stressed a need for more aerosol and atmospheric composition for use in model data assimilation due to the large and numerous data gaps that exist in ground-based networks in the United States. TEMPO will prove an invaluable asset for resolving these data issues over greater North America as a suite of aerosol and atmospheric composition data products on an hourly time scale will be disseminated in near-real time to the end-users. These data products will be extremely useful for improving model data assimilation and air-quality forecasts. Previous research efforts have shown the tremendous benefits in assimilating aerosol information from geostationary satellite instruments, which indicates that preparation is already well underway for the immediate use of TEMPO products in data assimilation systems once available. The presenters also mentioned that surface concentrations, especially for O_3, NO_2, and $PM_{2.5}$, and emissions at high spatial resolution from TEMPO will be especially beneficial for air-quality forecasting purposes.

Planning and Assessment

The presentations in this session highlighted a number of benefits that TEMPO data will bring to the planning and assessment community. There has been an increased focus on background air-quality levels due to the more stringent ambient air standards; however, the primary tools to assess the background levels are nested global/regional models with large uncertainties. Estimations of background air-quality levels will significantly improve when TEMPO measurements become available. The unique TEMPO measurements will also enhance our ability to capture the diurnal changes in air quality concentrations, improve our understanding of the weekday and weekend differences in NO_2 columns, and help better identify and define exceptional events. The presenters emphasized the use of TEMPO data for rigorous model evaluation activities as well. For instance, TEMPO data can be used for evaluating the ability of a model in capturing the intra-regional differences and dynamic changes in air-quality conditions. Figure 1 shows the Community Multiscale Air Quality (CMAQ) model predictions of NO_2 versus aircraft measurements of NO_2 over Bakersfield, CA, in January 2013. The aircraft measurements clearly reveal the poor performance of the CMAQ model during this high NO_2 transport event. The availability of TEMPO NO_2 will allow for similar model evaluation practices with nearly continuous measurements. This example also indicates the need for using TEMPO for improving data assimilation and air-quality forecasts.

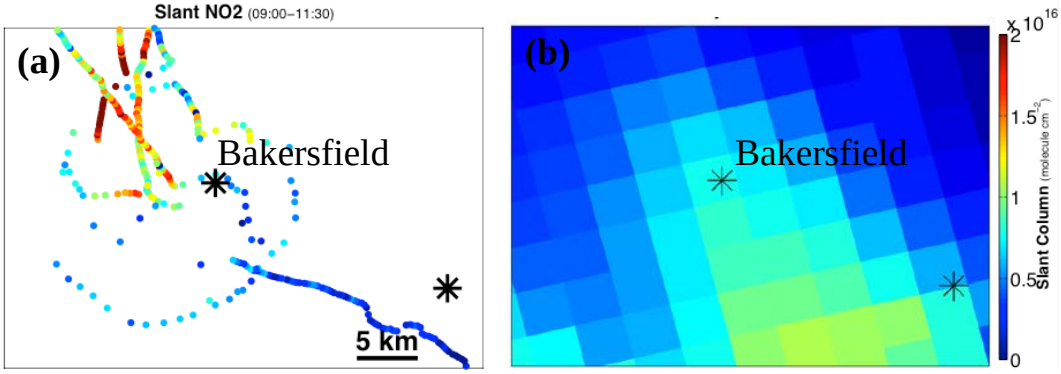


Figure 1. (a) Aircraft measurements of NO_2 columns between 0900 and 1130 UTC for a high NO_2 transport event in January 2013. (b) CMAQ model predictions of NO_2 for approximately the same time. Adapted from figure presented by Luke Valin (Columbia University/EPA).

Emissions

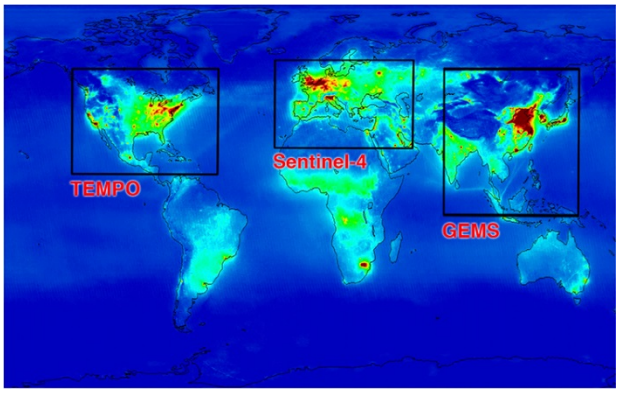


Figure 2. Approximate spatial coverage of the TEMPO, Sentinel-4, and GEMS instruments, which are funded geostationary spectrometers with expected launch dates from 2018-2020. Figure from presentation by Jeff Vukovich (EPA).

One of the critical messages throughout this session was that TEMPO data will help greatly improve our understanding of emissions compared to the low-earth orbiting (LEO) instruments. In particular, the hourly sampling and high spatial resolution of TEMPO measurements will allow for the evaluation of temporal variations, spatial mapping, and sector-specific emissions, which have yet to be realized from currently available ground-based and satellite measurements. The ability of TEMPO to spatially resolve urban emissions and chemistry and monitor these complex source regions is expected to be a tremendous asset for the end-user community. Furthermore, TEMPO will be able to characterize emissions from evolving sources, such as oil, natural-gas basins, and fires. Overall, the much improved emission inventories that will result from TEMPO data show great promise in helping assess control strategies for emissions. The presenters also stressed the importance of an internationally integrated observatory strategy employing complementary approaches between the TEMPO, Sentinel-4, and the Geostationary Environmental Monitoring Spectrometer (GEMS; Figure 2), in an effort to conduct policy-relevant science and environmental services through the common observations. Ultimately, this approach will improve emissions estimates at common confidence levels over the Northern Hemisphere and improve air-quality assimilation systems and forecasts.

Health, Agricultural, and Environmental Impacts

The presenter representing the health sector noted that the high temporal resolution, expected accuracy, and spatial coverage of TEMPO data will benefit acute health effect studies (e.g., asthma events linked to pollution) of $PM_{2.5}$, O_3, and NO_2. The presenter also noted that observations from TEMPO, given its limited expected life, would not be appropriate for studying chronic effects (e.g., heart attacks linked to long-term exposure). Although the spatial resolution of TEMPO will also benefit $PM_{2.5}$ and O_3 studies, it is not adequate for studying the acute health effects of NO_2; thus, the presenter highlighted the need to develop models to improve the spatial resolution of the NO_2 data. In order to study the acute health effects from pollutants using TEMPO data, the TEMPO retrievals must be converted to ground concentrations. The presenter for the agricultural and environmental sector emphasized the use of TEMPO data for quantitatively understanding local crop yield losses, along with spatial and inter-annual variability in losses. It was also noted that TEMPO data will help identify regions where use of O_3 resistant cultivars is valuable. Lastly, TEMPO NO_x measurements will help characterize the emissions from fertilizer applied to agricultural fields, which will facilitate assessments of the potential benefits of improved nitrogen use efficiency in fertilizer application for surface O_3 concentrations.

Day 2

The second day of the workshop focused primarily on the discussions and outcomes from 90-minute breakout periods that were led by program managers or their associates. However, two additional sessions focusing on end-user perspectives and training/decision support of TEMPO began the day.

End-User Perspectives

Presenters emphasized use of TEMPO data for identifying exceptional events for wildfires and stratospheric intrusions, estimating U.S. background O_3 concentrations, and characterizing international transport events. The enhanced spatial and temporal resolution of TEMPO will improve the ability to monitor smoke plumes and will help determine whether these plumes remain in the free troposphere or reach the surface and impact air-quality conditions. The higher temporal resolution of TEMPO may also help place more focus on regular pollution events instead of stressing only exceptional events.

Training/Decision Support

This session stressed Synergy between TEMPO and Geostationary Operational Environmental Satellite R-Series (GOES-R). In particular, the channels spanning the visible and infrared spectrum on GOES-R allows for the development of robust cloud-masking techniques. Conversely, the TEMPO instrument lacks these infrared channels, but the very-high spectral resolution in the ultraviolet and visible will allow for the development of robust aerosol detection techniques. Thus, TEMPO and GOES-R synergy will lead to overall more robust aerosol retrieval algorithms with reduced uncertainties. The presenters also stressed the need to identify other user-friendly systems for incorporation of TEMPO products in addition to the planned Remote Sensing Information Gateway (RSIG) interface. For example, the enhanced Infusing satellite Data into Environmental Applications (eIDEA) interface may be another great

outlet for TEMPO data. These presenters also noted that TEMPO is an applied mission; thus, rapidly demonstrating applications is necessary for influencing its perceived value.

Breakout Sessions

The breakout sessions concentrated on the four core science sessions from day one. Discussions during the breakout sessions focused on a list of questions that were provided to workshop attendees:

- TEMPO will provide first of its kind temporal (1 hourly) and spatial (2-km pixel width in north-south; 4.5-km pixel length in east-west) resolution with limited data latencies allowing for the community to continue existing applications and facilitate new ones. **What are the discipline or focus area science questions or application challenges that can be addressed with TEMPO data?**
- A variety of current and future partners exist in the community. **Who are your key partners or end user organizations on tasks, projects, or processes that use NASA satellite data? Who are additional potential users?**
- Given what you have learned about TEMPO over the last two days, **what additional or higher level data products from TEMPO might be useful in your science or applications tasks?** (Include the characteristics of the product and other requirements, e.g. resolution, accuracy, data latency, data format.) Rank them in importance.
- Within your organization, **what are the biggest impediments limiting your use of new satellite data and products?**
- **What data formats** (e.g., NetCDF, HDF, GIS-compatible, etc.) **do you need for your science or applications tasks?**
- There are a number of current in situ and remotely sensed data that measure atmospheric constituents, such as tropospheric ozone (O_3), nitrogen dioxide (NO_2), aerosols, and other trace pollutants (formaldehyde [H_2CO], glyoxal [$C_2H_2O_2$], and sulfur dioxide [SO_2]). **Which instruments/observations do you currently use for your work?**

Key outcomes from these breakout sessions are discussed below. The last two questions had similar responses from each breakout sessions; thus, these will be summarized together in one group followed by general comments.

Air-Quality Forecasting

Science Questions/Application Challenges: Improve characterization of background O_3 for regional air-quality prediction. Improved constraints on NO_x emissions and absorbing aerosol optical depth and aerosol heights will improve forecasts of O_3 production in fire plumes.

Users and Partners: State and local air-quality forecasters, global-scale modeling groups, Washington and Alaska Volcanic Ash Advisory Centers (VAACs), Pacific Northwest National Laboratory, U.S. Forest Service, Federal and State Forest Services, and airborne campaigns.

Key Products: (1) Quantification of uncertainty, detection limits, and any data aggregation or missing values. (2) Availability of a priori (and their observation error covariances where applicable) as well as sufficiently detailed information on retrievals and removal of stratospheric components. (3) Quality flags, observation-error standard deviation, observation-error correlation matrix, and averaging kernels where appropriate (e.g., ozone profiles). (4) Cloud information and their expected impact on the data product for any data provided in partly cloudy conditions. (5) Regional sub-setting capability to limit data volume.

Impediments: Latency as operational forecasting requires two-hour latency unless 24-hour analysis cycle is performed prior to forecast. Limited temporal sampling due to polar orbit, along with uncertainty estimates, retrieval sensitivities, lack of aerosol speciation, and retrieval artifacts (e.g., cloud clearing, surface reflectance, and land/ocean biases).

General Comments: (1) First time a suite of ozone pre-cursors, O_3, and $PM_{2.5}$ will be measured on an hourly time scale, which lends itself to investigating photochemical processes leading to ozone and $PM_{2.5}$ and to assess how this knowledge can help to improve model chemistry and thus predictions. The high spatial and temporal resolution of TEMPO will be valuable for regions of complex meteorological flows (i.e., mountain/valley flows, lake/sea breeze circulations). (2) Synergy between GOES-R and TEMPO will be critical for wildfire, lightning NO_x, volcanic ash, and aerosol/cloud interaction forecasting. Lightning-imager flash energetics can be used to get NO_x emissions estimates (use Gulf of Mexico observations to compare TEMPO NO_x column to GLM NO_x emissions). Coupling between aerosols, deposition and coastal ocean color should be expanded. TEMPO has wavelengths for ocean-color retrieval but lacks wavelengths for atmospheric correction. Intercomparison between TEMPO and GOES-R aerosol products will be valuable for understanding information content of different retrievals (useful for data assimilation constraints). (3) Use Geostationary Trace gas and Aerosol Sensor Optimization (GEOTASO) airborne instrument data as TEMPO proxy to demonstrate real applications of TEMPO data (i.e., emission constraints, improved ozone/aerosol forecast).

Planning and Assessment

Science Questions/Application Challenges: Impact of fires on O_3 and PM National Ambient Air Quality Standards (NAAQS) exceedances and dynamic fire emissions (opportunities to leverage the Fire and Smoke Model Evaluation Experiment (FASMEE) and the Fire Influence on Regional and Global Environments Experiment (FIREX)). Magnitude and temporal profile of NO_2 emissions (mobile), and optimal NO_2 and SO_2 monitor siting (power plants). Source apportionment of background contributions to O_3 and PM, and surface site representativeness and how it changes over time.

Users and Partners: United States Forest Service and fire community, private sector, emissions inventory community, and GOES-R and TEMPO groups (need to improve communication for synergy between instruments).

Key Products: (1) $PM_{2.5}$ speciation (separate dust from smoke, boundary layer from free troposphere). (2) Formaldehyde (HCHO): NO_2 for ozone sensitivity. (3) Averaging kernels or Level 2 products to allow for better model to observation comparison. (4) Fixed fields (e.g., O_2

dimer). (5) Store preprocessed observations for historical analysis (desire to go back several years and look at an event with high temporal resolution).

Impediments: Working with multitude of tools and formats (need interoperability), and integrating data from multiple platforms (e.g., GOES-R and TEMPO synergy).

Emissions

Science Questions/Application Challenges: Near-real time emissions observatories of NO_x and aerosols, and indirect constraints on primary volatile organic compounds (VOCs; formaldehyde, glyoxal). Top down constraints on temporal and spatial allocations for specific emissions sectors. Using TEMPO as a vehicle for establishing a more effective communication between end-users (e.g., inventory developers) and top-down analysis. Removes data gaps that are present in current LEO products.

Users and Partners: Environmental Protection Agency (EPA), NASA, NOAA, Department of Energy (DOE), United States Forest Service, United States Department of Agriculture (USDA), Department of Transportation (DOT), Federal Aviation Administration (FAA), Centers for Disease Control and Prevention (CDC), National Institute for Environmental Health Sciences (NIEHS), Bureau of Ocean Energy Management (BOEM), state and local agencies, industries (e.g., energy companies, transportation), urban development and coastal community planning groups, farming and agriculture groups, and academic agencies.

Key Products: (1) Chemical/meteorological data assimilation or fused data products (e.g., surface concentrations, surface mixing ratio) with TEMPO and other observations at all times. (2) Near-real-time emissions estimates. (3) Higher spatial-resolution derived products. (4) Higher temporal-resolution derived products.

Impediments: Ease of use, discovery (knowledge on existing tools), understanding and knowledge of proper application of products, limited collaboration/interaction with product teams which could mitigate the previously listed impediments, data volume and storage.

Health, Agricultural, and Environmental Impacts

Science Questions/Application Challenges: Gas phase pollutants (NO_2, SO_2, O_3) are a concern for human health, but TEMPO spatial coverage is not adequate for health data which is characterized by zip code (couple of square kilometers) and lack of nighttime coverage of TEMPO could be a concern for NO_2. Case-study applications of pollutants and determining source locations (health studies for respiration, agriculture studies with NO_2 and O_3).

Users and Partners: CDS, USDA, EPA, State Departments, World Health Organization (WHO), and United Nations Environmental Programs.

Key Products: (1) Merge TEMPO data with meteorological data (i.e., precipitation, temperature) important for PM and NO_2 originating from agriculture. (2) Multi-platform retrievals to improve spatial resolution and aerosol retrievals (need to get to river or estuary scale for water/ocean applications). (3) Most significant limitation of TEMPO is lack of vertical resolution; thus, need to use some surface assets (e.g., profilers) to provide boundary layer vertical information (for O_3 in particular) and have to integrate surface data with satellite information for calibration and validation. (4) Satellite profiles which can help understand the

dynamical mixing occurring (DISCOVER-AQ finding showed that surface measurements did not capture the column very well). (5) TEMPO need to plan for dynamic applications which vary over time and require continued support for product development for end users.

Impediments: Need to make information relevant to end users as information is often too complicated to understand.

Common Responses

Instruments/Observations Currently Used: AIRNow, Ozone Mapping Instrument (OMI; i.e., total ozone, absorbing AOD, tropospheric NO_2, SO_2 column, trend analysis for emission adjustment), the Moderate Resolution Imaging Spectroradiometer (MODIS), the Visible Infrared Imaging Radiometer Suite (VIIRS), GOES, Advanced Himawari Imager (AHI), Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) and Cloud-Aerosol Transport System (CATS) aerosol extinction products for validation purposes, Multi-angle Imaging SpectroRadiometer (MISR), Atmospheric Infrared Sounder (AIRS) O_3 product, and Aerosol Robotic Network (AERONET), along with other ground instruments.

Data Formats: HDF files are valuable because they allow for large amounts of mission data and metadata to be compressed. However, this format is not the easiest to use for all end users. Other data formats of high value include GIS layer files (e.g., ArcGIS), KML for Google Earth, BUFR, and NetCDF files. It was also noted that the data formats are less important than providing readers for the data in various languages (e.g., C, Fortran, IDL, MATLAB, Python, etc.) so that end-users are able to read and access the data. Having the data available in near-real time on sites that enable automated download and analysis was also noted as important for operational use of the data. Data availability by latitude and longitude and on a grid. Subsetting capabilities by time, region, and species.

Appendix I: Workshop Agenda

Tuesday, July 12:

7:30a – 8:15a Registration/Continental Breakfast

8:15a – 8:25a UAH Welcome, Sundar Christopher, Dean College of Science, UAH

8:25a – 8:35a NASA Applied Sciences Welcome, John Haynes, Program Manager, NASA/HQ.

8:35a – 8:45a NASA HQ Welcome, Barry Lefer, Tropospheric Composition Program Manager, NASA/HQ

8:45a – 9:15a TEMPO Mission Overview and Status, Kelly Chance, Senior Physicist, TEMPO Principal Investigator, Smithsonian Astrophysical Observatory, Harvard-Smithsonian Center for Astrophysics

9:15a – 9:30a Value of Applications for TEMPO, Doreen Neil, NASA/LaRC

Session 1: Air Quality Forecasting (Session Chair: Brad Pierce)

9:30a – 9:35a Session Introduction: Brad Pierce, NOAA/NESDIS

9:35a – 9:55a The National Air Quality Forecast Capability, Ivanka Stajner, Manager, National Air Quality Forecast Capability, NOAA/National Weather Service (NWS)

9:55a – 10:15a Rapid Refresh of Anthropogenic NOx Emissions with Fused Satellite and Ground NO2 Observations to Support Real-timeAir Quality Forecasting, Pius Lee, NOAA/ARL

10:15a – 10:30a Morning Break

10:30a – 10:50a Impacts of Assimilation of Air Quality Data from Geostationary Platforms on Air Quality Forecasts, Greg Carmichael, Professor, University of Iowa

10:50a – 11:10a Global and regional air quality forecasting and assimilation relevant to the TEMPO mission, Richard Menard, Research Scientist, Air Quality Research Division, Environment and Climate Change Canada

<u>Session 2:</u> Planning and Assessment (Session Chair: Terry Keating)

11:10a – 11:15a Session Introduction: Planning and Assessment using TEMPO, Terry Keating, Senior Scientist US EPA Office of Research and Development

11:15a – 11:35a Opportunities for TEMPO to Advance Air Quality Management and Exposure Assessment, Tim Watkins, Deputy Director, National Exposure Research Laboratory, Office of Research and Development, USEPA

11:35a – 11:55p Observing NO2 from above, from below and at the surface – insights from a data user, Luke Valin, Postdoc, LDEO, Columbia University

11:55a – 12:15p Initial Thoughts on the Benefits of TEMPO data for Air Quality Management, Pat Dolwick, Physical Scientist, U.S. EPA Office of Air Quality Planning and Standards

12:15p – 1:15p On-Site Lunch

<u>Session 3:</u> Emissions (Session Chair: Ron Cohen, Professor UC Berkeley)

1:15p – 1:20p Session Introduction: New Insights into emissions using TEMPO observations, Ron Cohen, Professor, UC Berkeley

1:20p – 1:40p TBD, Jeff Vukovich, Physical Scientist, USEPA/OAQPS/EIAG

1:40p – 2:00p TEMPO Applications to Emissions Quantification and Understanding, Gregory Frost, Research Chemist, NOAA Earth System Research Laboratory

2:00p – 2:20p Smoke Modeling Supporting Wildfire and Prescribed Fire Operations, Susan M. O'Neill, Air Quality Scientist, USDA Forest Service

Session 4: *Health, Agricultural, and Environmental Impacts (Session Chair: Mike Newchurch, Professor UAH)*

2:20p – 2:25p Session Introduction: Mike Newchurch, Professor, UAH

2:25p – 2:45p Satellite applications in air pollution health research, Yang Liu, Associate Professor, Emory University

2:45p – 3:05p Using TEMPO to Evaluate the Impact of Ozone on Agriculture, Denise L. Mauzerall, Professor, Princeton University

3:05p – 3:30p Afternoon Break

3:30p – 3:50p Tropospheric Ozone Enhancement Due to Lightning – Observations and Models, Lihua Wang, Research Associate, UAH Earth Systems Science Center

3:50p – 4:10p Estimating volcanic ash emissions by assimilating satellite observations with the HYSPLIT dispersion model, Tianfeng Chai, Associate Research Scientist, NOAA-ARL/University of Maryland

4:10p – 4:30p TEMPO & Coastal Interdisciplinary Science: Capturing Diurnal Variability of Coupled Anthropogenic and Biogeochemical Processes, Carolyn Jordan, Associate Research Fellow, National Institute of Aerospace

4:30p – 5:00p Day 1 Wrap-Up/Open Discussion

5:00p Adjourn Day 1

Wednesday, July 13:

7:30a – 8:00a Registration/Continental Breakfast

Session 5: End-User Perspectives (Session Chair: Mike Newchurch)

8:00a – 8:05a Session Introduction: Mike Newchurch

8:05a – 8:25a A Web System Application Framework for use of Remote Sensing Obs in Air Quality Planning, Tom Moore, WRAP Air Quality Program Manager, WESTAR Council

8:25a – 8:45a Data Needs for Model Evaluation for Ozone Attainment Plans, Gail Tonnesen, Air Quality Modeler, USEPA

8:45a – 9:05a Use of Satellite Data for Georgia's Air Quality Planning Activities, Tao Zeng, Modeler, Data and Modeling Unit, Georgia Environmental Protection Division, Air Protection Branch

9:05a – 9:25a TEMPO Relevance to the Air Monitoring Community, Kathy Jones, Air Monitoring Manager, Chattanooga-Hamilton County Air Pollution Control Bureau

Session 6: Training/Decision Support (Session Chair: Bradley Zavodsky)

9:25a – 9:30a Session Introduction: Bradley Zavodsky, Research Meteorologist, NASA/MSFC

9:30a – 9:50a GOES-R/TEMPO Synergy and Air Quality Proving Ground Activities, Shobha Kondragunta, NOAA/NESDIS (view presentation) PPTX

9:50a – 10:10a NASA's Applied Remote Sensing Training Program, Pawan Gupta, Research Scientist/ARSET Air Quality Lead, USRA/GESTAR/GSFC/NASA (view presentation) PPTX

10:10a – 10:30a EPA Remote Sensing Information Gateway; A Perspective on Facilitating User-Developed Applications, Jim Szykman, Senior Research Engineer, U.S. EPA Office of Research and Development (view presentation) PPTX

10:30a – 10:45a Morning Break

Breakout Discussions/Capture End User Perspectives

10:45a – 10:50a Introduction and Goals, John Haynes, Program Manager, NASA/HQ

10:50a – 12:20p Breakout Discussions (led by session chairs; local scribes)

1. Air Quality Forecasting (Lead: Brad Pierce)
2. Planning and Assessment (Lead: Terry Keating)
3. Emissions (Lead: Ron Cohen)
4. Health (Lead: Bradley Zavodsky)

12:20p – 1:30p Lunch/Breakout Leads Prepare Reporting

1:30p – 2:30p Breakout Leads Report Back (15 minutes each)

2:30p – 3:00p Discussion of Early Adopter Possibilities for TEMPO

3:00p Adjourn Meeting

Appendix II: List of Registered Attendees

First Name	Last Name	Affiliation
FNU	Alisha	Texas A&M University at Galveston
Dale	Allen	UMCP
Jay	Al-Saadi	NASA
Matthew	Alvarado	AER
Muhammad	Barik	Washington State University
Roberto	Basaldud	INECC
Greg	Beachley	US EPA
Martin	Belavić	Meteorological and Hydrological Service Croatia
Emily	Berndt	UAH/NASA SPoRT
Timothy	Bertram	UW Madison, Department of Chemistry
Cassia	Beu	IPEN-USP
Salvador	Blanco	National Institute of Ecology and Climate Change
Stjepana	Brzaj	Meteorological and Hydrological Service Croatia
Darijo	Brzoja	Meteorological and Hydrological Service Croatia
Kaylin	Bugbee	GHRC DAAC
Zhaonan	Cai	
Lawrence	Carey	UAH
Greg	Carmichael	University of Iowa
Tianfeng	Chai	NOAA/ARL
Kelly	Chance	Smithsonian Astrophysical Observatory
Ian	Chang	UAH
Alex	Charleston	CDC
Sheng-Po	Chen	
Peiyang	Cheng	UAH
Sen	Chiao	San Jose State University
Mian	Chin	NASA GSFC
Ronald	Cohen	UC Berkeley
Damjana	Ćurkov	Meteorological and Hydrological Service Croatia
Allison	Daniel	UAH/NASA DEVELOP
Bruce	Doddridge	NASA Langley Research Center
Pat	Dolwick	USEPA OAQPS
Prakash	Doraiswamy	RTI International
Joel	Dreessen	Maryland Dept. Environment
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