Seasonal Report

2021 Ozone

OVERVIEW

Maryland ozone levels in 2021 remained consistent with the previous few years (excluding 2020) and had a lower number of exceedances compared to the past 20+ years. Surface ozone is a secondary air pollutant created through the interaction between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. The "ozone season" is the period between April and September where more direct sunlight, warm temperatures and generally weak surface winds provide a suitable environment for ozone formation. Surface ozone concentrations are monitored and forecasted over this time period to help protect the public's welfare. Unlike ozone in the upper atmosphere that shields the Earth from harmful solar radiation, ground level ozone adversely affects the human respiratory system. Some examples include reduced lung function, inflammation of airways, chest tightness and shortness of of breath. The Air Quality Index (AQI) (see bottom of page) was developed by the Environmental Protection Agency (EPA) to easily communicate air quality status to the public. When the daily 8-hour average ozone concentration exceeds 70 parts per billion (ppb), or 100 on the AQI scale, it is deemed unhealthy for sensitive groups (USG). Days in which the 8-hour average meets this criteria are called "exceedance days". A total count of exceedance days each year can be a key indicator of the ozone season's severity. Maryland recorded just 17 ozone exceedance days in 2021.

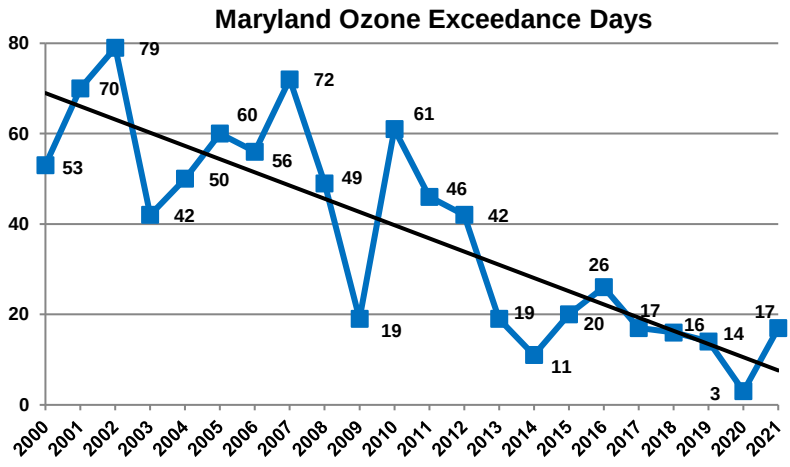

Figure 1: Total number of Maryland ozone exceedance days using the EPA 2015 70 ppb standard, 2000 – 2021. Black trend line is included.

SEASONAL HIGHLIGHTS & STATISTICS

Meteorologically, conditions were quite favorable for ozone formation across the state of Maryland during the 2021 season. Apart from May, temperatures were typically well above seasonal norms. Maryland's Baltimore/Washington International Thurgood Marshall Airport (BWI) recorded 52 days reaching or exceeding 90˚F in 2021. This is 20 days above the normal average and was the 4th highest number of 90º days in BWI's recorded history. Precipitation was slightly above average for the season but had periods of dry weather particularly during the April – July timeframe. Despite this, Maryland was tied for the 5th fewest ozone exceedance days ever in 2021.

Although Maryland saw an increase in the number ozone exceedance days versus 2020 (See Figure 1), it is important to note that COVID-19 restrictions during the summer of 2020 had the effect of reducing emissions causing it to not represent typical conditions. Ozone exceedance day counts in 2021 were more in line with the 2017-2019 timeframe despite the intense heat.

Widespread ozone exceedance day events have become few and far between in recent years. Of the 17 ozone exceedance days

Maryland 2021 Ozone Exceedance Days

Date	Day	No. of Monitors	Highest AQI Monitor	8-Hr Average Ozone AQI
19 May	Wed	4	Aldino	122
20 May	Thu	7	Frederick	126
21 May	Fri	1	Rockville	112
22 May	Sat	1	Aldino	105
5 Jun	Sat	8	Aldino	122
6 Jun	Sun	2	Essex & Edgewood	108
18 Jun	Fri	1	Aldino	101
30 Jun	Wed	1	Edgewood	108
6 Jul	Tue	1	Fairhill	101
7 Jul	Wed	1	Essex	108
20 Jul	Tue	1	Essex	126
27 Jul	Tue	3	Essex	126
28 Jul	Wed	6	PG Equest Center	112
6 Aug	Fri	4	Essex & Padonia	105
12 Aug	Thu	1	Aldino	101
13 Aug	Fri	1	Essex	126
25 Aug	Wed	5	Padonia	140

Table 1: Maryland 2021 ozone exceedance days. Day of week is noted along with highest reading monitor and its color coded 8-hr AQI value.

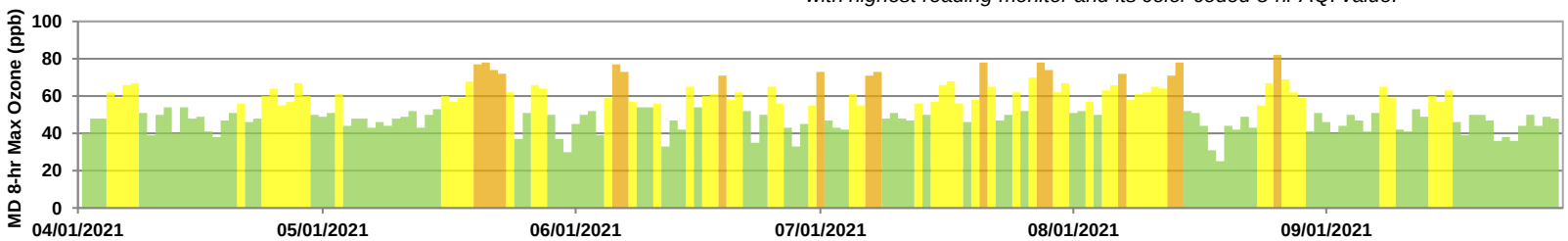

Figure 2: Maximum daily 8-hour ozone concentration (ppb) in Maryland from April 1 – September 30, 2021. Bars are color coded by AQI.

AQI	0-50 Good	51-100 Moderate	101-150 USG*	151-200 Unhealthy	201-300 Very Unhealthy	301-500 Hazardous

*Unhealthy for Sensitive Groups based on 2015 8-hr ozone NAAQS.

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SEASONAL HIGHLIGHTS & STATISTICS (*cont.*)

in Maryland, nine were triggered by just one monitor (~53%) with many of these events just squeaking over the 70 ppb standard (See Table 1). 2021 also saw zero days reaching Unhealthy (Code Red) ozone levels. The last Unhealthy ozone exceedance day dates back to July 10th, 2018. As local and regional NO_x levels continue to decline, it has become difficult to reach these high ozone concentrations despite even the most favorable of meteorological conditions.

The influence of summer season wildfire smoke transported long distances into Maryland is becoming a growing concern as climate change leads to the enhancement of drought conditions across the Western US and Canada. Wildfires are emitters of both NO_x and VOCs, the two major components needed for the formation of ground level ozone. The Hazard Mapping System (HMS) came online in 2002 and has become a very important tool to track wildfire and associated smoke plumes. HMS uses existing air sensors and a suite of environmental satellites to create a daily fire and smoke analysis map over the US and Canada. During the 2021 ozone season, HMS analyzed smoke over Maryland on 13 of the 17 ozone exceedance days (~76%). This is a drastic increase versus the previous few years. Of the 50 ozone exceedance days between 2017 and 2020, HMS analyzed smoke over Maryland on just 5 (~10%)! For the latest HMS products and information, please visit here.

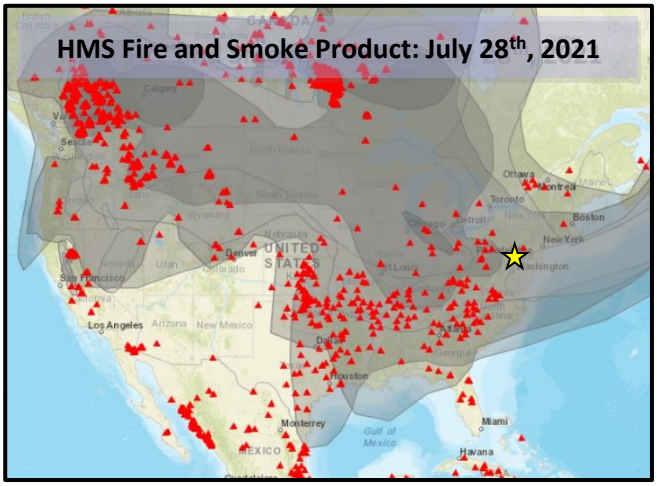

Figure 3: HMS Fire and Smoke Product for one of more widespread ozone exceedance days in 2021, (July 28th). Red triangles indicate fire locations and shaded grey areas indicate areas of smoke. Darker greys signify denser smoke. Baltimore location is noted by a yellow star. Smoke across the Mid-Atlantic on this day primarily originated from wildfires across south-central Canada and the Pacific Northwest.

Tropospheric Emissions: Monitoring of Pollution (TEMPO)

The Tropospheric Emissions: Monitoring of Pollution or TEMPO satellite-based instrument is a NASA EVI (Earth Venture-Instrument) that will measure pollution across North America. By measuring sunlight reflected and scattered from the Earth's surface and atmosphere back to the instrument's detectors, TEMPO's ultraviolet and visible light sensors will provide measurements of ozone, nitrogen dioxide and other near-surface pollutants in near real-time.

TEMPO will be the first ever space-based instrument to monitor air pollutants hourly across North America. This is a major improvement in the current frequency capabilities. TEMPO will be able to achieve this given its geostationary orbit, the first air quality satellite of its kind. At roughly 22,000 miles above the Earth's equator, this high orbit allows the satellite to match the Earth's rotation and maintain a constant view over North America. Past air quality satellites were all polar orbiting. Polar orbiting satellites fly at much lower altitudes compared to geostationary and in doing so can only provide a single snapshot (but at high resolution) over a particular area each day. Despite TEMPO's distance from the Earth's surface, the spatial resolution will be better than any prior air quality satellite. Figure 4 below showcases TEMPO's spatial resolution versus other previous satellites (OMI and GNOME-2). At 2 km x 4.5 km, TEMPO will be able to resolve pollution at sub-urban scales.

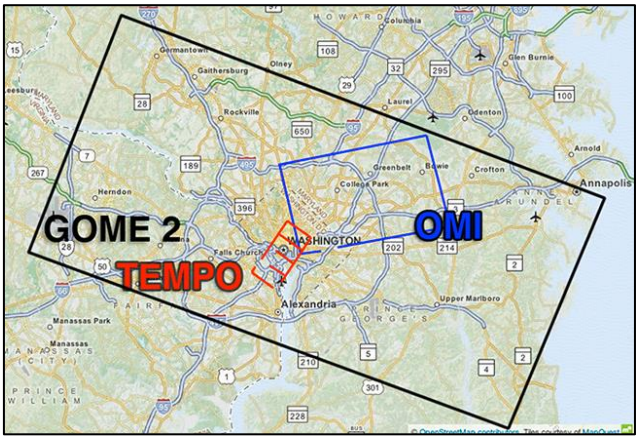

Figure 4: Visual comparison of TEMPO's spatial resolution versus prior air quality satellites (GOME-2 and OMI) around Washington DC. The TEMPO mission will measure air pollution at 355 times the resolution of the GOME-2 satellite, and 50 times the OMI satellite's spatial scale. (*Credit: tempo.si.edu*)

TEMPO is being launched alongside two other pollution-monitoring satellites, Europe's (Sentinel 4) and Asia's (GEMS) (*See Figure 5*). The three instruments together will form a network for air quality monitoring for future years, with a major focus on intercontinental pollution transport across the Atlantic and Pacific oceans. Data from TEMPO, Sentinel-4, and GEMS will also revolutionize air quality monitoring and forecasting. Given a limited number of ground-based ozone and other air quality measurements, these satellites will help to fill in the gaps at both spatial and temporal resolutions that are unrivaled in current air quality satellites. The TEMPO instrumentation is planned to be launched aboard a SpaceX Falcon 9 launch vehicle in either late 2022 or early 2023.

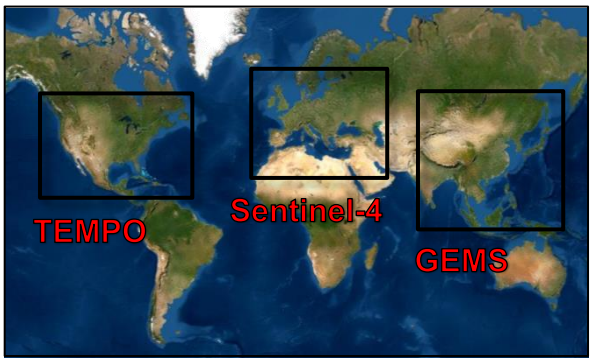

Figure 5: Names (in red) and approximate viewing extents (black boxes) of the three geostationary air quality satellites to be launched (Source: tempo.si.edu).

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