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HAZE AS HIGH ALTITUDE AIR POLLUTANT, CENTRAL & SOUTH ASIA, INTRODUCING EARTH ROTOR ELECTRO-KINETIC YAW

***[1]Commodore Ranjan Roy, [2]Gangadhar Andaluri and [3]William C. Miller**

[1]AQ, PA-DEP, College of Engineering, Temple University, Philadelphia
[2]Lab Manager and Adjunct Professor, Civil and Environmental Engineering, Temple University, Philadelphia
[3]Associate Professor, Civil and Environmental Engineering, Temple University, Philadelphia

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ABSTRACT

Airplane exhaust and rocket fuel at high altitudes add small quantities of air pollutants and haze from partly combusted fuel. The high altitude haze is long-lived, regional, and transported by jet streams. The high altitude haze life-time (half-life probability) is greater than at the ground. The data on carbon dioxide emissions from international travel and Southern Asiatic mountain shields may be representative of the haze. Also, any air pollutant heavier than the ambient air exerts signature physical properties. Plume in the higher altitude imparts insignificant *mass-yaw* on the rotating Earth rotor. However, research on the haze *electro-kinetic* yaw based on the Maxwell equation (electromagnetic torque) is non-existent. This paper provides some insight into the potential future research areas on haze transport and electro-kinetic yaw on the Earth rotor.

INTRODUCTION

According to the US-EPA, haze is one of the most basic forms of air pollution that impair the visibility. When Aerosols in the air encounter sunlight, some light is absorbed and the rest scattered, resulting in a reduced clarity (US-EPA - https://www.epa.gov/visibility/visibility-basic-information). Particulates such as sulfates and nitrates significantly enhance the light scattering during humid conditions leading to increased haze. Under the right conditions atmospheric haze is observed near the ground during low wind conditions. It has been reported that the average visibility is reduced by 75% to 85% in the parks regions in the United States (US-EPA, measured by light extinction method or other method). It is well known that atmospheric pollutant (agricultural nutrients, particulate matter, persistent organic pollutants, etc.) has an impact at a global scale (NRC 2009). Application of nutrients (sulfates and nitrates) for farming can add to the ground level haze. These sulfates and nitrates may be lifted off the ground by normal atmospheric, photochemical, and meteorological mixing processes (tornadoes or twisters) and transported to higher altitudes, which will then contribute to the high altitude haze.

***Corresponding author: Commodore Ranjan Roy,**
AQ, PA-DEP, College of Engineering, Temple University, Philadelphia.

Atmospheric scientists are trying to collect data to understand the aerosol (haze) radiation effect and cloud, by flying P3 and other airplanes with instruments at 20,000 feet and up to 65,000 feet (NASA 2016); there is a reference to the ground fire and smoke transporting to the cloud level (ORACLE project). At the ground, haze may also result from city area source plume or fossil fuel combustion. It can also be observed downstream of coal-powered plants or forest fires, as well as in a river basin under the valley effect between two hills. According to the US-EPA Air Pollution Training Institute (APTI) training manual, the coarse particulate matter from a point source tends to gravitate. Still, some fine particulate matter remains suspended in the air. It is known that aerosols are formed from condensation and chemical processes (Malm, W. C. 1999). The aerosols in the size range from 0.01 micrometer (µm) to 1.0 µm diameter grow principally by gas-to-particle conversion. Molecules diffuse to the surface of a particle and subsequently are incorporated into the particle. The particle coagulation and condensation takes place in the atmosphere (UKDE 1993). Gas-to-particle conversion processes, including transformation of gaseous hydrocarbons from vegetation, generate the largest amount of aerosols in the atmosphere (Kouimtzis and Samara 1995). The fossil fuels' background electromagnetic signature sampling tends to suggest a hypothesis that some fuel and carbon residue in the air may be polar and *electro-kinetic*. Haze can also be observed high above the ground, which is often referred to as high altitude haze (Clark, B.A.J. 1968; Deming, D. 1982; Lammer, H. 1999). It was reported that the North American skies experience haze at an altitude of approximately 1,000 meters (m) to 1,200 m [3,000 feet (ft) to 4,000 ft]. The jet streams and the cross winds help the haze dispersion (Hogan 1981). It was also observed that as the representative regional haze plenum, the South Asian and Indian subcontinent countries have mountain entrapment on three sides. The regional haze observed from commercial flights is as high as 4,500 m (~15,000 ft.) above Central India. It was reported that haze is partly reduced during the monsoon period (June through September) and during the winter and spring months an increased anthropogenic haze was observed over South and Southeast Asia (Ramanathan et al. 2001a). The main focus of this paper is high-altitude haze, its transportation and possible electrokinetic yaw effects on Earths rotor.

Evaluation

High altitude haze appears to be long-lived because of the following reasons:

- Air is dry
- Barometric pressure is low
- Above the cloud line, some fine particulate matter is not removed by the rain or cloud condensing nuclei (Seinfeld and Pandis 2006). Above the convective weather current, the stable aerosol clouds can persist for more than a year (Kouimtzis and Samara 1995). As a result, removal of oxides of carbon, nitrogen, and sulfur (CO_2, CO, NO_x, and SO_x) is slower than at the ground level
- Photolysis of the pollutants in the haze is questionable under the dry air and water molecules and
- Mountain chains block haze dispersal. For example, in the Appalachian range haze and clouds appear to be as persistent as the monsoon clouds in the INS Shivaji mountainside located in Maharashtra, India. In such cases, haze has to drift higher and then disperse beyond the mountain boundary.

Assessment of the regional haze plume at high altitudes is vital for safe environment. The high altitude haze data is limited or not available. Therefore, it is appropriate to review a surrogate gas or pollutant. Haze matter and carbon dioxide (CO_2) emissions from fossil fuels are heavier than ambient air. Based on a power plant's high momentum plume, the haze precursors are carried downwind for long distances by the exhaust plume where they eventually react and mix completely into the ambient air (Evans, C., PA-DEP). It is also known that long-lived greenhouse gas such as CO_2 undergoes global-scale transport (NRC 2009). Therefore, the exhaust plume could be considered as the carrier of ambient air haze; and CO_2 plume could potentially be regarded as a carrier of the ambient air haze and an indicator of the haze dispersion potential. Deming et al. 1982 have measured CO_2 spectroscopy as an evidence for high altitude haze thickening on Venus (Deming, 1982), which further strengthens the assertion that CO_2 could be considered a carrier of ambient haze. However, the plume *roto-dynamics* and *electro-kinetic* yaw effects on the earth rotor need further investigation.

DATA AND DISCUSSION

Haze & CO_2: The Netherlands Environmental Assessment Agency and the European Commission's Joint Research Center (EDGAR 2013) report includes the CO_2 emissions for the top 20 countries and international travel. The 2013 emissions in million kilo tons (mkt) for the top five countries are as follows: China ~10.5 mkt, U.S. ~5.5 mkt, European Union (EU) 3.5 mkt, India 2 mkt, International Travel ~1.8 mkt, and Russia ~1.4 mkt. The international travel and India (IT&I) are similar; their combined figure appears similar to EU skies. The combined impact of all three on a region appears greater than the U.S. The EU and South Asiatic emissions merit attention. It is known that haze transports from Europe to Asia, also from Asia to America. (Jaffe Dan et al. 1999, and Newell R.E., and Evans M.J. 2000). Central and South Asia appear to have the substantial high altitude haze. The air pollution transport to and from North America is significant in the spring, at different latitudes and altitudes (Cooper O.R., and Parrish D.D. 2004). The CO_2, CH_4, and N_2O are long-lived (> 1 year); so they are circulated globally, and obtain a reasonably uniform hemisphere-wide distribution.

Based on the available information and data from aviation traffic turbine and fuel, the largest contributor to the high altitude haze might be flights in North America and West Europe. From the Coriolis Effect and jet stream, the haze from the United States drifts and disperses into the North Atlantic skies, and the Canadian haze tends to drift towards the Arctic rim. They dissipate quicker, with greater wind speeds, and in lower altitudes as compared to the European and South Asian haze plume (NRC 2009). Chemical, microphysical and meteorological factors determine the fate of air pollutants released into the atmosphere. The location of the pollutant influences its transportation, both vertically and horizontally. When the pollutants are dispersed vertically, they encounter stronger winds, which then transport them to distant locations (NRC 2009). Jet streams are known to be an important distributor of air pollutants since they can create a significant air-exchange between different layers of atmosphere including troposphere and stratosphere, and rapidly transport the pollutants (NRC 2009). According to the National Academy of Sciences, the jet stream carries European haze to Central Asia within 1-2 weeks (NRC 2009). Some of the haze eddy dip south into regional haze and tend to stay on longer due to dry air and slower south-eastern winds. The Indian haze is marked by the convection (Chung et al. 2003; Schott et al. 2009), until buoyed up to the top of the Karakoram and Himalayan mountain ranges, and it might drift southeast due to lower elevation, through the Arakans Myanmar hill range.

The haze drifts seasonally. The directional energy effect of sunrays is a special phenomenon. At high altitudes within latitudes up to ~ 40 to 45 degrees, where human habitation causes haze, radiant energy from the sun may energize this haze matter for longer than the 12-hour daylight. This scenario may be observed for approximately nine months. The solar radiant energy has a potential to induce ionizing effects on the atmosphere. Also, the molecular drifting of haze to the north and beyond can result from a combination of sunrays, jet streams, Coriolis effects, and earth rotor gyro effect in the Northern Hemisphere (NRC 2009). The high altitude haze is subject to gas adsorption. Some haze is fine particulate matter and some of it is condensate (water molecules on NO_x and SO_x) (NRC 2009). Based on EDGAR 2013 data, the CO_2 and haze plume at high altitudes impose yaw effect on the atmospheric circulation and the earth rotor, as the Indian subcontinent's haze does. The combined total is between 4 to 5 million kilo tons of CO_2, which is greater than the EU and

Canada together (EDGAR 2013). These high altitude emission rates are the third largest, next to China and U.S. The regional plumes mass loading and torque on the Earth's rotor are lower compared to the severe volcanic eruption from the Philippines' Mt. Pinatubo in 1991 (USGS 1997). It ejected roughly 10 billion tons (10 cu. km, 2.4 cu. mi) of magma, and 20 million tons of SO_2. It also ejected more particulates into the stratosphere than any other volcanic eruption since Krakatoa in 1883. Over the following months, the aerosols formed a global layer of sulfuric acid haze. This resulted in a global temperature drop of approximately 0.5 °C (0.9 °F) during 1991–93. However, there is no data on the haze matter and its *electro-kinetic* yaw effect.

The extreme weather events report highlights "*Non-meteorological factors can limit the accuracy of model simulations of extreme events and confound observational records. Drought and wildfire are examples of events for which non-meteorological factors can be especially challenging in attribution studies*". It also includes three research studies: "*modeling, extend the historical observational record, and improvements in remote sensing products that extend long enough to document trends and sample extremes.*" (National Academy of Sciences 2016).

In this context, the following two conclusions are noteworthy:

- The Mauna Loa annual concentration and increments 3-D modeling by authors contain some anomalies, which can be attributed to human-made or natural CO_2 emission spikes. They throw off the future trend analyses and graphs.
- The long-lived haze at high altitude can scatter energy (incident radiation and the following irradiation), to reduce the night-time thermal irradiation back to space, and thereby increase the regional night-time air temperatures, experienced in Russia, UK, and Europe.

Electro-kinetic phenomenon

Electro-kinetic phenomenon is defined as a family of several different effects that occur in heterogeneous or porous bodies filled with fluid or in a turbulent flow over a flat surface. *Electro-kinetic* phenomenon is inherent to fluid motion, charge alignment, and modulated transport (Wall, S. 2010). This phenomenon may also applicable to the haze transport in the atmosphere. The *electro-kinetic* fundamentals, from the elemental molecular outer orbit electron to rotational moments, could be determined from the following principles:

- Linear motion of a polar molecule, such as water
- Fleming's left hand rule
- Rotational yaw derived from Maxwell equation for electrical flux to torque
- Electrodynamic pulse from the electrical capacitance charge and discharge of compounds, particulate matter, and fuel combustion residue
- The Earth's geographical/geomagnetic axes, buoyancy, and the axial modulation

Yaw

Yaw is used to describe the twisting or oscillation of moving aircraft or ship around vertical axis (Longo et al. 1996). Since, Earth is in motion relative to the Universe, we can apply similar principles in describing the effect of haze on Earth's rotation. The haze matter yaw effect on the earth is assessed to be extremely low. However, it is a recognizable haze for research on: quantification, thermal scattering, irradiation, and *electro-kinetic* torque effects on the earth rotor gyro. Adhikari et al. 2016 have reported a shift in the Earths rotational axis and have attributed it to the terrestrial water storage (Adhikari et al. 2016). However, it could be partly due to the polar flight, regional haze drift, and the dispersion of the haze. Haze life-time is greater at higher altitudes because the dry air has less hydrogen and oxygen ionic reactions, the air is thin, and the relative vapor pressure is low. Therefore, the incremental haze plume in the thin air might result in a greater yaw or rotational effect on Earth than otherwise assumed. Earth rotor gyro yaw is a phenomena based on the precessional rate. Earth surface speed is trans-sonic and similar to the gyro rotor surface speed and the consequential yaw tracking. At high altitudes, the air mass imbalance is like a gyroscopic yaw tracking more quickly, and may appear as a pulse on the optimum yaw on the ~7.5 degree axis of the earth wobble. It is apparent from the basic mechanics studies that any human-made momentum changes and any human-made haze heavier than ambient air must impart a yaw effect to the earth rotor's gyro yaw; it may be inconsequential from the *mass-yaw* perspective, but its *electro-kinetic* effects as the pulse type of yaw should be evaluated and equated to the electrical track and imprint on the earth rotor's very small electrical field and flux. In this context, these fundamental questions are important:

- Does this phenomenon add to the lightning precursors in ambient air humidity at altitude?
- Does the airplane exhaust haze add to this *electro-kinetic* yaw effect?

Since regional high altitude haze experiences the daylight longer than at the ground, late in the afternoon until dusk, it might result in a radiant energy incidence updraft, at a greater rate than the downdraft. Thus, the haze plume tends to gain altitude. The principle of haze height modulation between the day and night is an extension to *electro-kinetic* study and other assessed characteristics such as:

- Diurnal mass and *electro-kinetic* moment change on the earth yaw at the location of the haze plume;
- An equal reaction to the Earth's crust on the other side of the globe, adding to sun-tide bulge;
- During midday the crustal expansion and its resonance may coincide with that of the haze, located halfway around the globe;
- The resonating extra-long wave impulse may be measured from the periodic spikes in the tidal bulge.

SUMMARY

The regional haze has insignificant *mass-yaw* (compared to the rotor mass); however, it appears to be significant *electro-kinetic* yaw on the earth rotor (compared to the background electro-magnetic field and modulation). The regional haze may initiate insignificant gyroscopic imbalance from the high altitude air pollutants that are heavier than ambient air (carbon dioxide, oxides of nitrogen, particulate matter, high temperature resistant military flight fuel additives residue, and rocket fuel residue). The haze plumes of concern are: Central Asian drift from European skies and the Indian subcontinent, also East Asian drift from Northeastern China. They merit research to reduce the high altitude regional haze and the Earth rotor *electro-kinetic* yaw. Further, the aging turbines on commercial and military airplanes pollute more than new gas turbines and must be phased out. The high altitude haze can be reduced partly by new generation airplane engines and missile burners, to cut emissions. Under the Clean Air Act, the U.S. Environmental Protection Agency (USEPA) has promulgated regulations designed to improve visibility in the nation's largest national parks and wilderness areas (Class I area). The Regional Haze Rule is found in 40 CFR Part 51.308. The states are required to submit State Implementation Plan (SIP) reports every five years. For example, Minnesota has two Class I areas; they submitted a report in 2014 (Minnesota SIP 2014). The haze measurement standards require updates to estimate the regional haze, starting with the US EPA's established light extinction or deciview haze index [D_v] for a visual range [V_R] intended for a pristine area (USEPA, 2003). A new haze standard for the airport air [short line of sight], high altitude air corridor [medium line of sight], and a region [long line of sight] is recommended.

Conclusion

The NAS 2016 recommendation for future modeling and studies must be implemented. Also, the haze *electro-kinetic yaw, its regional and global impact on the earth rotor* should be studied. The USEPA and UNWMO must promulgate that high altitude haze is long-lived like the CO_2 and other air pollutants (CH_4, N_2O). International flights should be fitted with monitors to measure particulate matter ($PM_{2.5}$ & PM_{10}) to access the high altitude haze and its transport. Also, they can be fitted with CO_2 sensors to study the transport of CO_2 in relation to haze. The data obtained by measuring haze transport could shed some light on the shifting Earth's rotational axis and electro-kinetic effects. High altitude air pollutant life-time study could be a new chapter in the *electro-kinetic* and hydro-dynamic physics.

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Disclaimer

Opinions, Findings, discussions, and conclusions presented in this study are those of the authors and do not necessarily reflect the views of PA Department of Environmental Protection or Temple University.

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