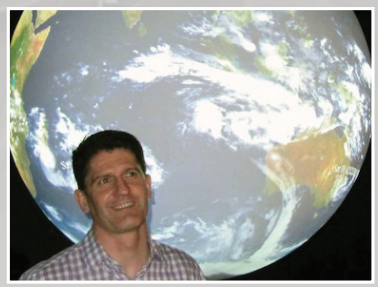
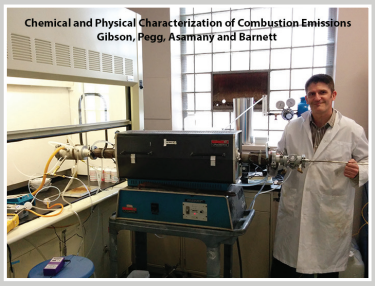
How will the testing be done?

A team of students, specialists, and Lafarge staff, under the supervision of Dr Gibson will conduct extensive baseline tests to measure kiln performance and emissions prior to the use of scrap tires and will then repeat these tests when using scrap tires and analyze and compare results. These results will be shared with the public. The emission tests themselves consist of independent analyzers drawing gases from the stack in addition to a team of specialists who climb the stack in order to draw out stack gases through a series of filters and solutions to capture all of the compounds. The samples are sent to specialized environmental laboratories and all of the data is put together to report on the concentrations of the compounds measured. The testing methodologies follow government approved methods.





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Utilizing TEMPO surface estimates to determine changes in emissions, community exposure and environmental impacts from cement kilns across North America using alternative fuels

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ABSTRACT

Managing solid waste from residential and non-residential sources is a major challenge faced by all North American (NA) governments. One way to mitigate the need to expand landfill sites across NA is waste diversion for use as alternative fuel in industries such as cement manufacturing plants. Currently, waste plastic, tires, waste shingles and other high carbon content waste destined for landfill are being explored, or currently used, as alternative supplemental fuels for use in cement kilns across NA. While this is an attractive, environmentally sustainable solution, significant knowledge gaps remain in our fundamental understanding of whether these alternative fuels may lead to increased air pollution emissions from cement kilns across NA.

The long-term objective of using the NASA Tropospheric Emissions Monitoring of Pollution (TEMPO) remote sensing package is to advance fundamental understanding of uncharacterized air pollution emissions and to assess the actual or potential environmental and health impacts of these emissions from cement kilns across NA. TEMPO measurements will be made in concert with in-situ observations augmented by air dispersion, land-use regression and receptor modelling.

BACKGROUND

This application of TEMPO follows current research on a series of bench scale and pilot studies for a local cement plant which investigated the change in combustion emissions from various mixtures of coal (C), petroleum coke (PC) and non-recyclable alternative fuels. From our work we demonstrated that using an alternative fuel mixture containing mixed plastics in a cement kiln has potential to reduce emissions of CO2 by 34%; reduce NOx by 80%, and reduce fuel SO2 emissions by 98%.

OBJECTIVE

To advance the fundamental understanding of combustion emissions associated with cement kilns utilizing alternative fuels from bench scale and pilot studies; and to assess actual environmental and health impacts associated with fuel change across NA through the application of satellite based remote sensing.

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FIGURE 1: Potential sources of plastic waste derived alternative fuels before and after size reduction. Such plastic films and crushed containers contain large quantities of energy which could displace a reasonable fraction of coal/coke.

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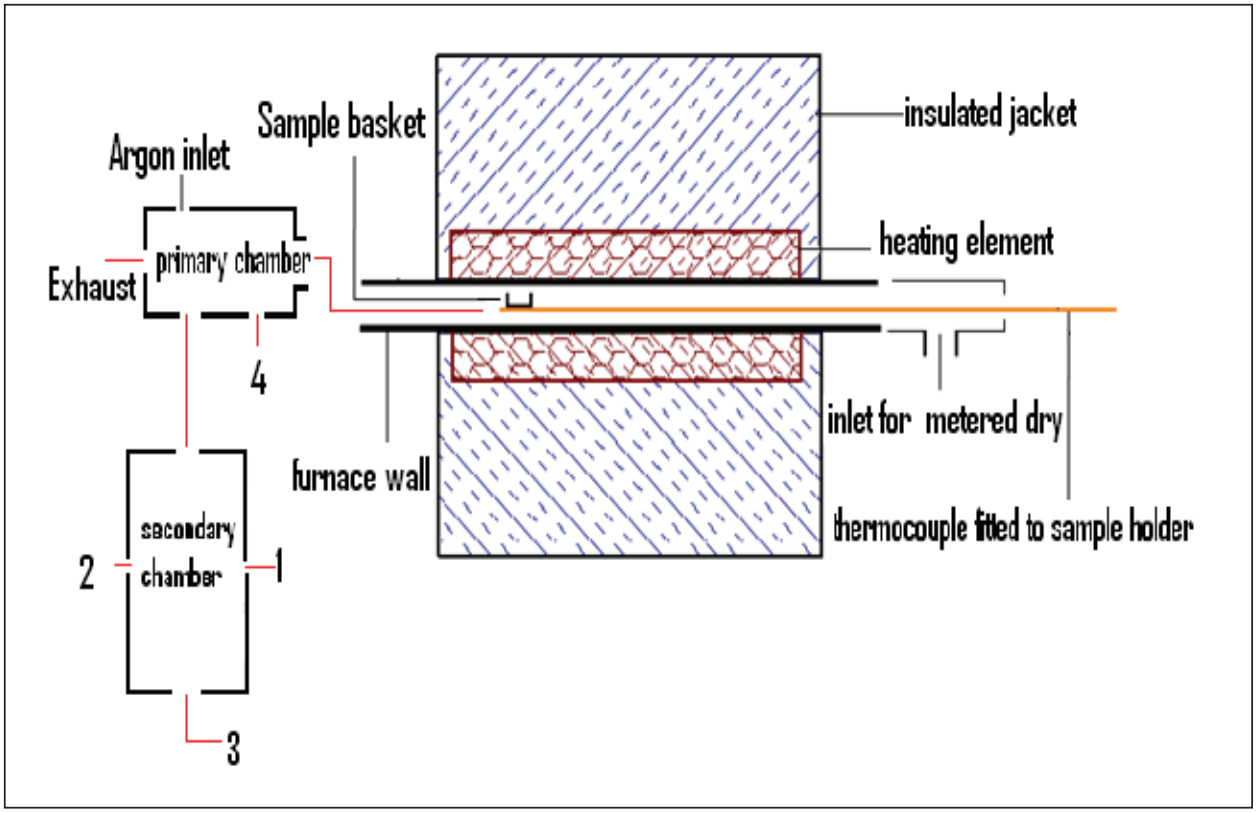

FIGURE 2: A cross-section of a modified tube furnace attached to gaseous and particulate emission detection devices. The set up was used for combustion studies on selected plastic-based waste materials to be used in a local cement kiln. Predictions of expected changes using only this approach, shown in Figure 4, are limited in scale and may require field observations to validate bench scale predictions.

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EXPERIMENTAL TECHNIQUES

Translating bench scale predictions to globally monitored observations

- Bench scale furnaces with attached emissions detection devices (Figure 2)
- The application of air dispersion, source apportionment, land use regression;
- The new NASA TEMPO satellite offering remote sensing to track dispersion plumes from cement kilns. The scope of the study is shown in Figure 3

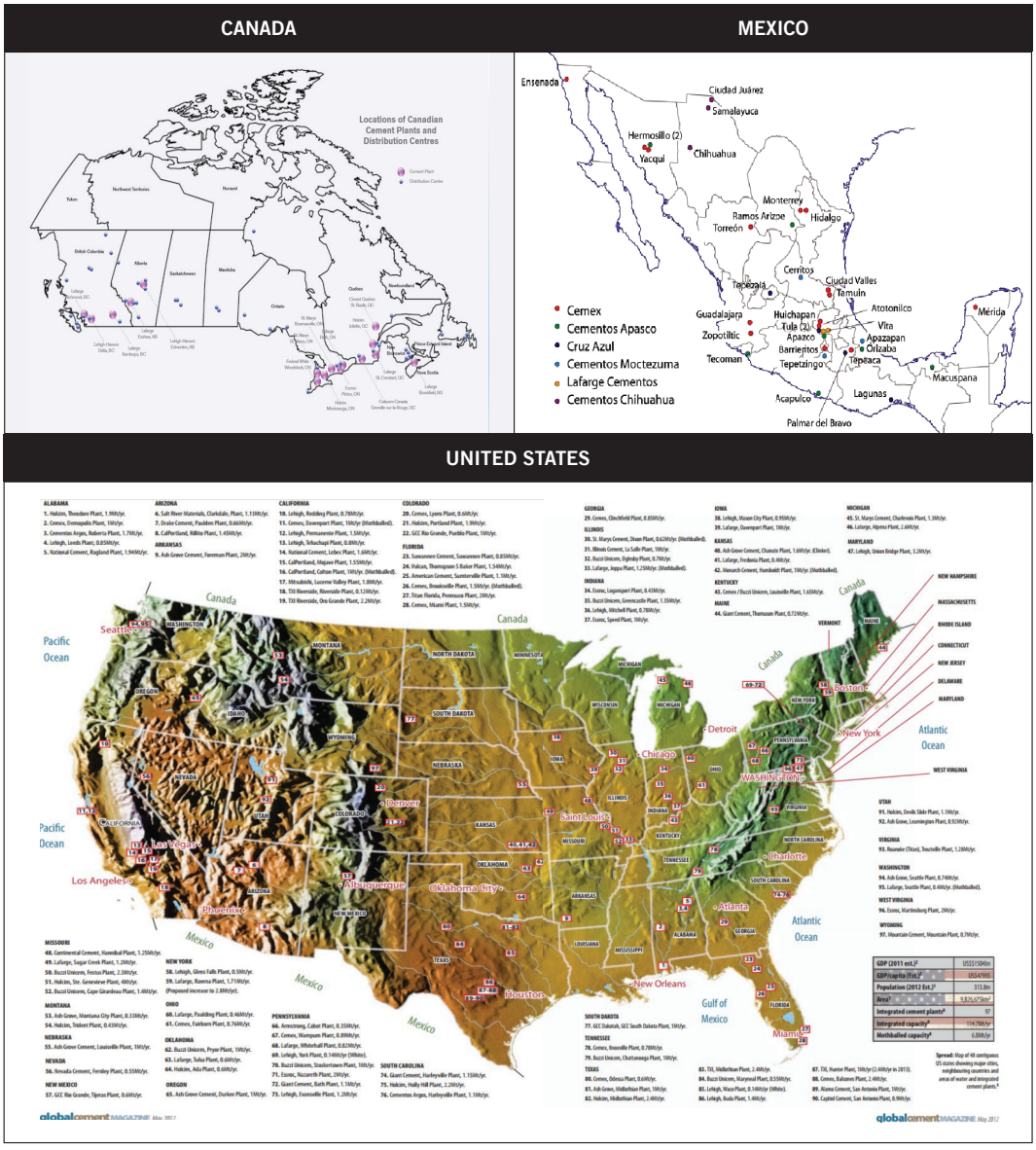

FIGURE 3: Showing a distribution of cement plants across the three major cement producing countries in North America Canada, Mexico and USA. In all, more than 100 cement plants across North America with potential to use some form of alternative fuel could be monitored for changes in emissions to a fine detail.

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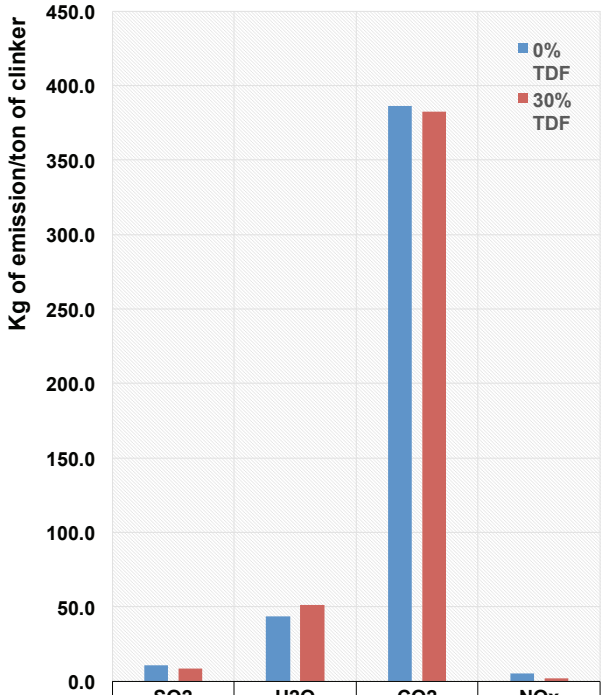
EXPECTED RESULTS BASED ON PRELIMINARY STUDIES

A

Comparison of gaseous emissions for 0% *TDF* and 30% *TDF* in fuel mix of kiln supplying 4.5GJ/tonne of clinker



	SO2	H2O	CO2	NOx
0% TDF	10.7	43.9	386.5	5.4
30% TDF	8.4	51.4	382.6	2.0

B

100% equivalent heat substitution of coal-coke fuel for selected *waste plastic based* fuels

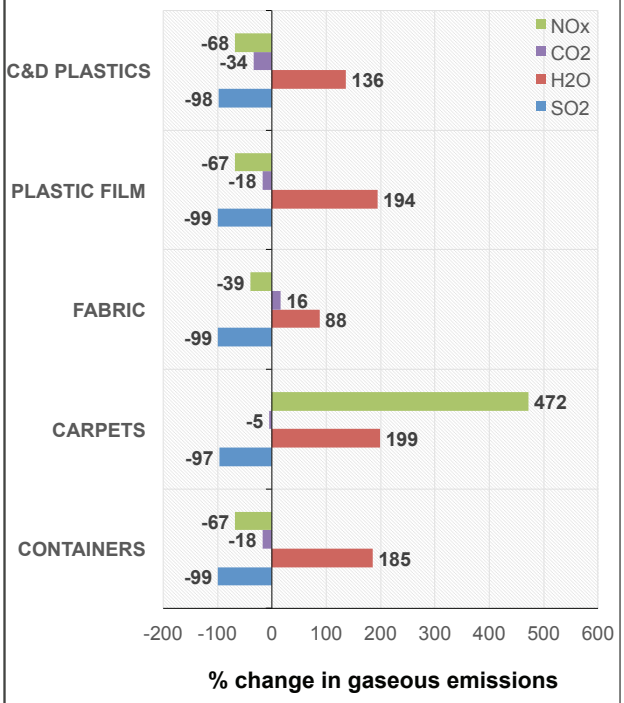


FIGURE 4: Estimations of expected changes based on ultimate analysis and stoichiometric combustion of selected waste based alternative fuels are shown for (A) Tire derived fuels (TDF) and (B) plastic based waste. These calculations are used, in conjunction with a tube furnace set up (Figure 2), to predict expected stack emission changes in particulates and gaseous compounds. Satellite monitoring will confirm if these predictive methods are within reasonable range.

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TEMPO

TEMPO will measure atmospheric pollution covering most of North America, from Mexico City to the Canadian tar/oil sands, and from the Atlantic to the Pacific hourly and at high spatial resolution. TEMPO is part of the Earth System Science Pathfinder satellite constellation (Figure 5).

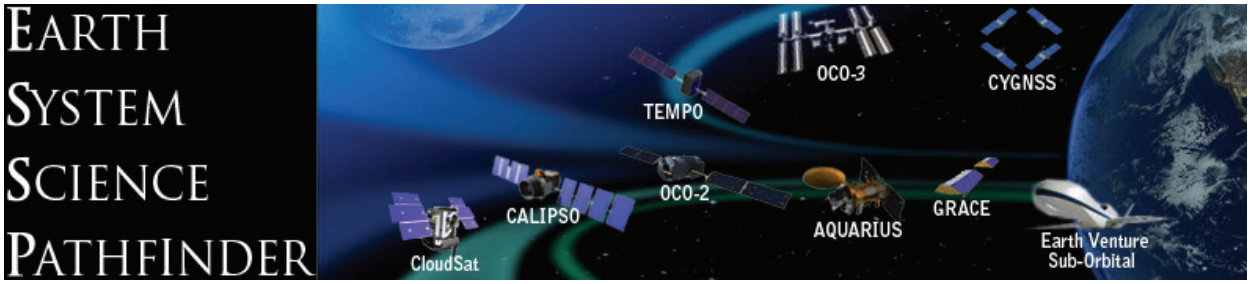

FIGURE 5: Earth System Science Pathfinder

TEMPO's field of regard is shown in Figure 6 below (courtesy of NASA/Harvard Smithsonian).

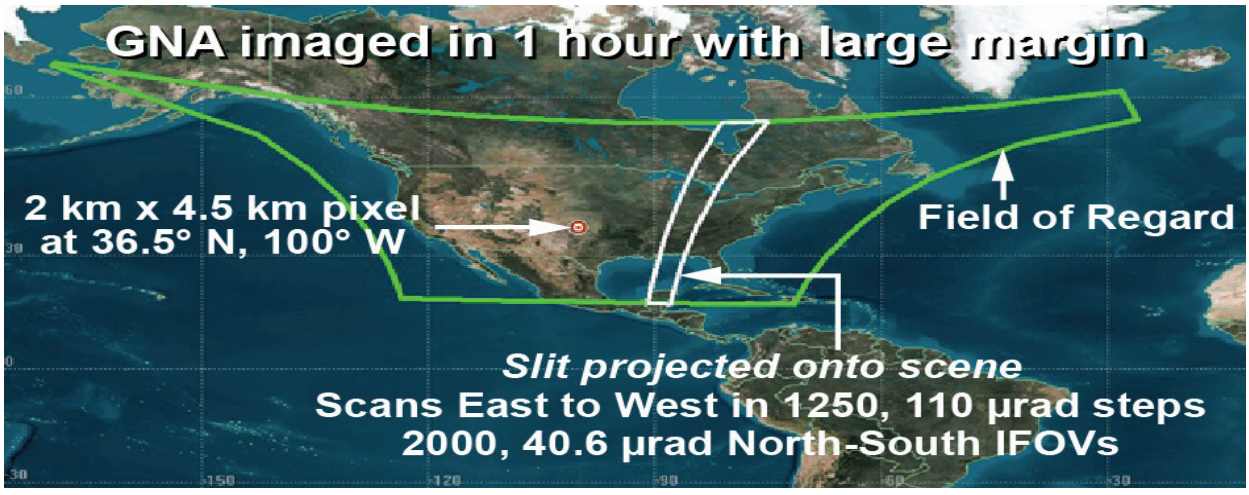

FIGURE 6: TEMPO field of regard (courtesy of NASA/Harvard Smithsonian)

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TEMPO MEASUREMENTS

TEMPO is scheduled for launch in 2017. Measurements will be made from geostationary orbit (GEO) of tropospheric ozone, ozone precursors, aerosols, and clouds [1]. TEMPO measurements include:

- Spatial Resolution: ~8.44 × 4.65 km or better at the center of the field of regard.
- PM2.5 – primary and secondary air pollutant and ± climate forcer.
- Ozone – secondary air pollutant and secondary aerosol precursor ± climate forcer.
- Nitrogen dioxide – local combustion marker and ozone & secondary aerosol precursor.
- Formaldehyde (H2CO) – marker of aged aerosol.
- Glyoxal (C2H2O2) – marker of aged aerosol.
- Sulphur dioxide – local combustion marker and secondary aerosol precursor.

TEMPO SCIENCE QUESTIONS

1. What are the spatiotemporal variation in emissions of gases and aerosols that are important for air quality and climate?
2. What are the atmospheric processes that determine tropospheric composition and air quality?
3. How does air pollution drive climate forcing and how does climate change affect air quality on a continental scale?
4. How can observations from space improve air quality forecasts and assessments for societal benefit?
5. How does intercontinental transport affect air quality?
6. How do episodic events, such as wild fires, dust outbreaks, and volcanic eruptions, affect atmospheric composition and air quality?

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CONCLUSION

On an equivalent heat basis, the use of a selection of plastic based waste could potentially reduce CO2, NOx and SO2 by ~ 5-35%, 40-70% and 98% respectively as seen in bench scale tests [2]. Calculations on emission changes for a practical substitution rate of 30% Tire Derived Fuel (TDF) for coal-coke fuel predicts reduction in fuel SO2, CO2, and fuel NOx by 21%, 1%, and 23% respectively [3]. Given the waste management incentive and the downward trend in pollutant emissions associated with the use of otherwise waste materials as alternative fuels in cement kilns; the practice has been recommended as environmentally sustainable. Tracking actual emissions changes of kilns by TEMPO will fill significant gaps in the effects of alternative fuels on cement kiln emissions on a larger scale.

FUTURE WORK

We aim to work with Lafarge cement Inc., other cement companies and NASA to facilitate the application of TEMPO to investigate changes in emissions from cement kilns in NA using alternative fuels.

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