Stratospheric Smoke to Rival Sulfate: the pyroCb Plume of 2017

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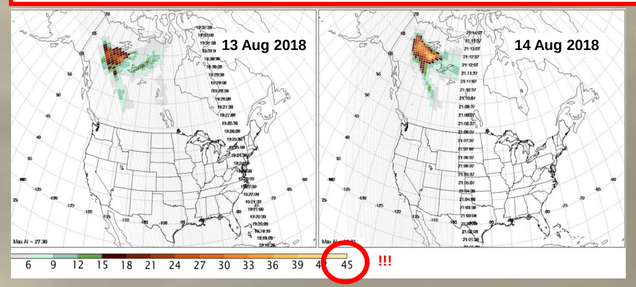
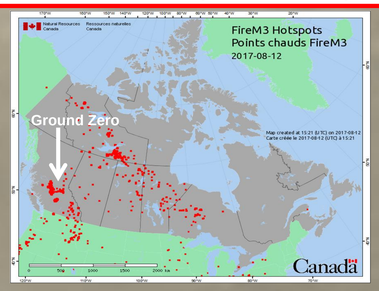
Abstract

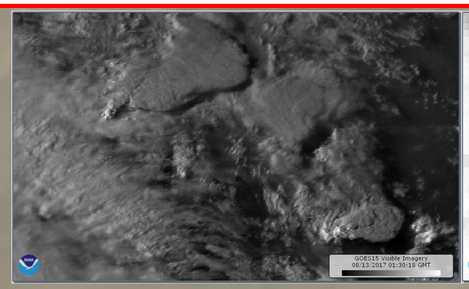
On 12 August 2017 a cluster of pyrocumulonimbus (pyroCb) storms erupted in British Columbia. This event directly injected biomass burning aerosols and gases into the stratosphere, and various satellite measurements have shown the emissions to be extremely large and possibly unequaled. These measurements exhibited an assortment of saturation issues and confounding signals. For example, GOME2, OMI and OMPS UV absorbing aerosol index values increased for several days in the core of the smoke plume. Profilers such as CALIPSO reached total attenuation in a stratospheric smoke layer. Limb profilers such as OMPS/LP effectively saturated 3-10 km above the tropopause.

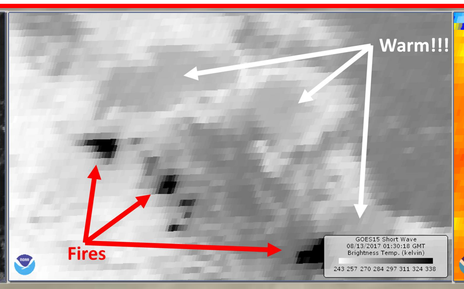
The pyroCb smoke plume rivals in at least one other measure certain volcanic clouds. By one month after injection the plume was observed at altitudes within the Junge layer: 25 km (Θ ~600 K). At times the summertime plume was observed upwind, over, and downwind of the Asian Summer Monsoon region. Considering these factors, this event stands as strong example of a non-volcanic pathway into the lower stratosphere that may contend with medium volcanic eruptions for its stratospheric aerosol perturbation potential.

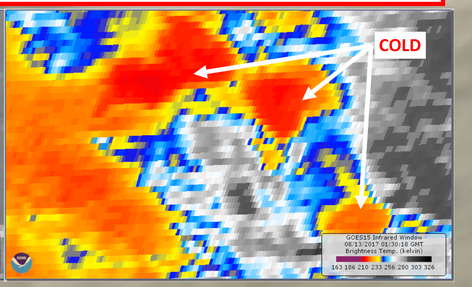
We analyze this pyroCb event with an assortment of satellite and ground-based aerosol and gas measurements to characterize the mass, spread, persistence, and impact of this powerful example of a recurring non-volcanic source of perturbed atmospheric composition.







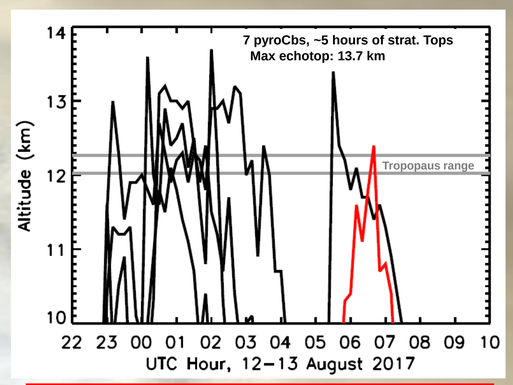




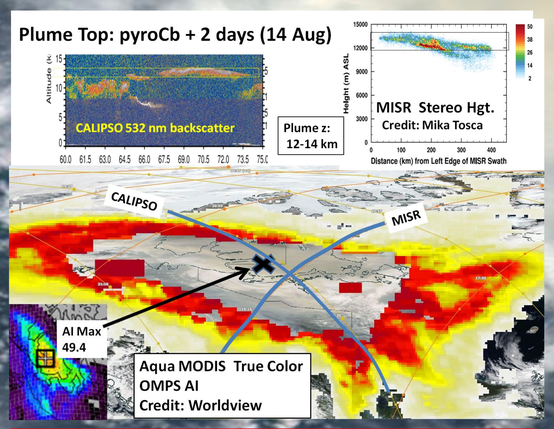
On 8/13 the max AI was 39.9. From 1979 – 2017 the TOMS-OMI-OMPS AI never exceeded 36.7.
On 8/14 the max AI surged to 49.4. Such an increase within a plume has never happened.
On 8/15 it increased to 49.7. Unprecedented. NO VOLCANO has created anything like this.

OMPS AI: The “Day-after” smoke plume | **Hot Spot: BC PyroCb cluster** | **GOES visible** | **GOES 3.9 μm temperature** | **GOES 11 μm temperature**

PyriCb & Immediate Aftermath

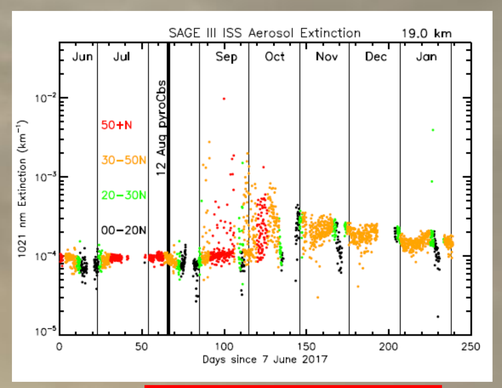


Injection Height: radar echotops
~13.7 km max
~tropopause to trop.+1.3 km

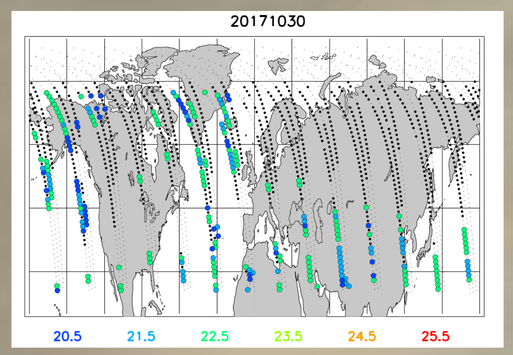


Plume Height: Earliest Observations
~12-14 km
~compare with radar echotops

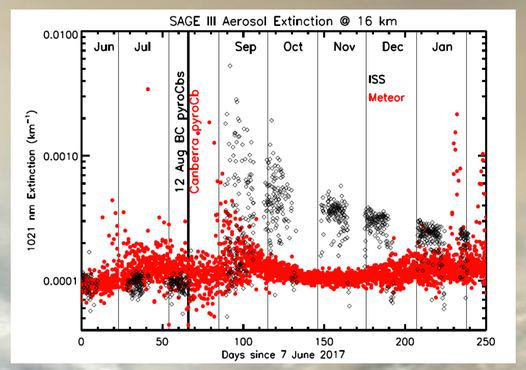
Plume Evolution: Transport, lofting, decay



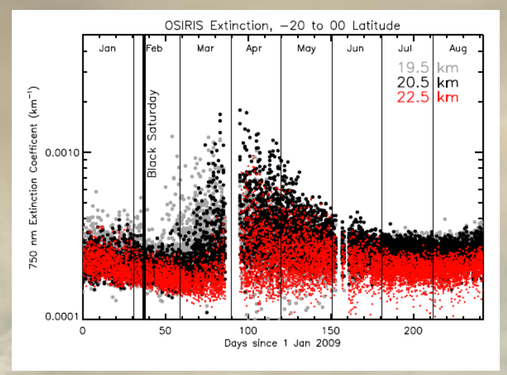
SAGE III ISS 1021 nm extinction, 19 km
*** NH latitude bands color coded**



OMPS/LP Aerosol Scattering Index Stratospheric Plume Detection
*** Tiny black points: OMPS profile location – no plume**
*** Black dots: plume-top < 20 km**
*** Colored, large dots: plume-top > 20 km (see scale above)**



SAGE III ISS, Meteor 1021 nm extinction, 16 km
*** 2017 BC pyroCb – black**
*** 2003 Canberra pyroCb, red.**
*** Time series fixed on pyroCb dates**



Black Saturday Plume evolution
*** OSIRIS 750 nm Extinction, SH Tropics**
*** Three altitudes shown (see legend)**
*** Black Saturday pyroCb date: thick vertical line**

Apples to Apples*: Comparison of 3 Top PyroCb Events
? Where does BC2017 fit in ?

* All confirmed as pyroCb based on radar echo-top and lightning observations

pyroCb Event	Injection z[1]	Post-injection z[2,3]	Top z[3]	Duration[3] (months)
Chisholm	14 km	12 km	18 km	3
Black Saturday	15 km	17 km	23 km	4
BC2017	13 km	13-14 km	24 km	6+

1 - Based on radar echo tops
2 - One or two days post-pyroCb
3 - Based on published works (Chisholm and Black Saturday)

Chisholm (Alberta, Canada, 28 May 2001):
Rosenfeld et al. (ACP, 2007)
Fromm et al. (JGR, 2008)

Black Saturday (Victoria, Australia, 7 February 2009):
Siddaway and Petelina, (JGR, 2011)
Pumphrey et al. (ACP, 2011)
Dowdy et al. (JGR, 2017)

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