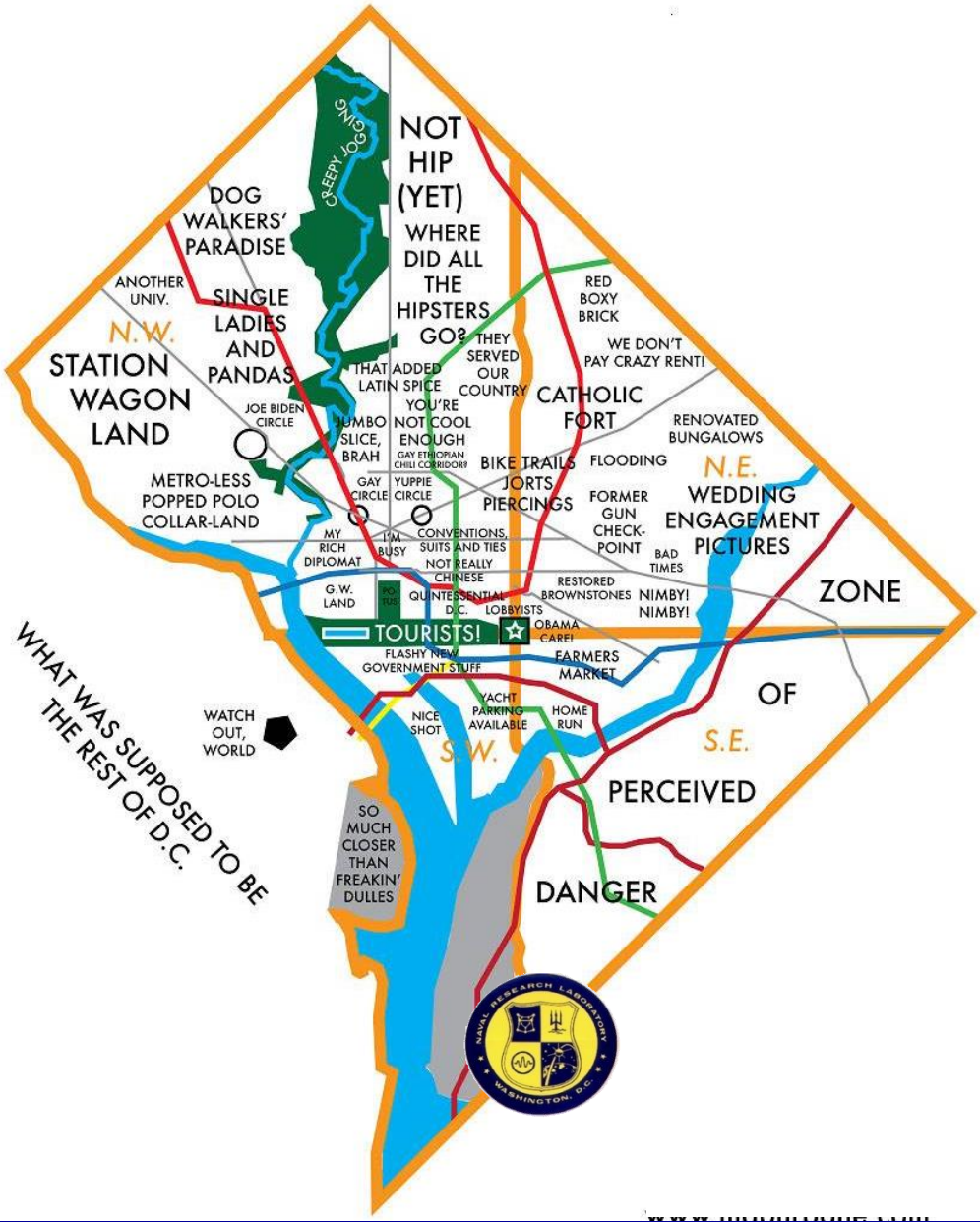
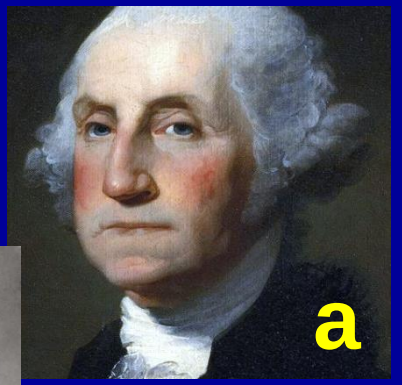




Mike Fromm, Naval Research Laboratory
Washington, DC

Particlelarly Interesting Science: the Meaning, Marvels and Mysteries of Pyrocumulonimbus

Grimsvötn (Iceland) volcano June 2011

Warm Fire (Arizona) pyroCb June 2006

Mike Fromm, Naval Research Laboratory 13 April 2016

Pyro

Pyrocumulus (pyroCu)

- condensation but no ice, no lightning

Pyrocumulonimbus (pyroCb)

- subset of pyroCu
- ice cloud
- lightning, hail, tornado
- can penetrate the tropopause

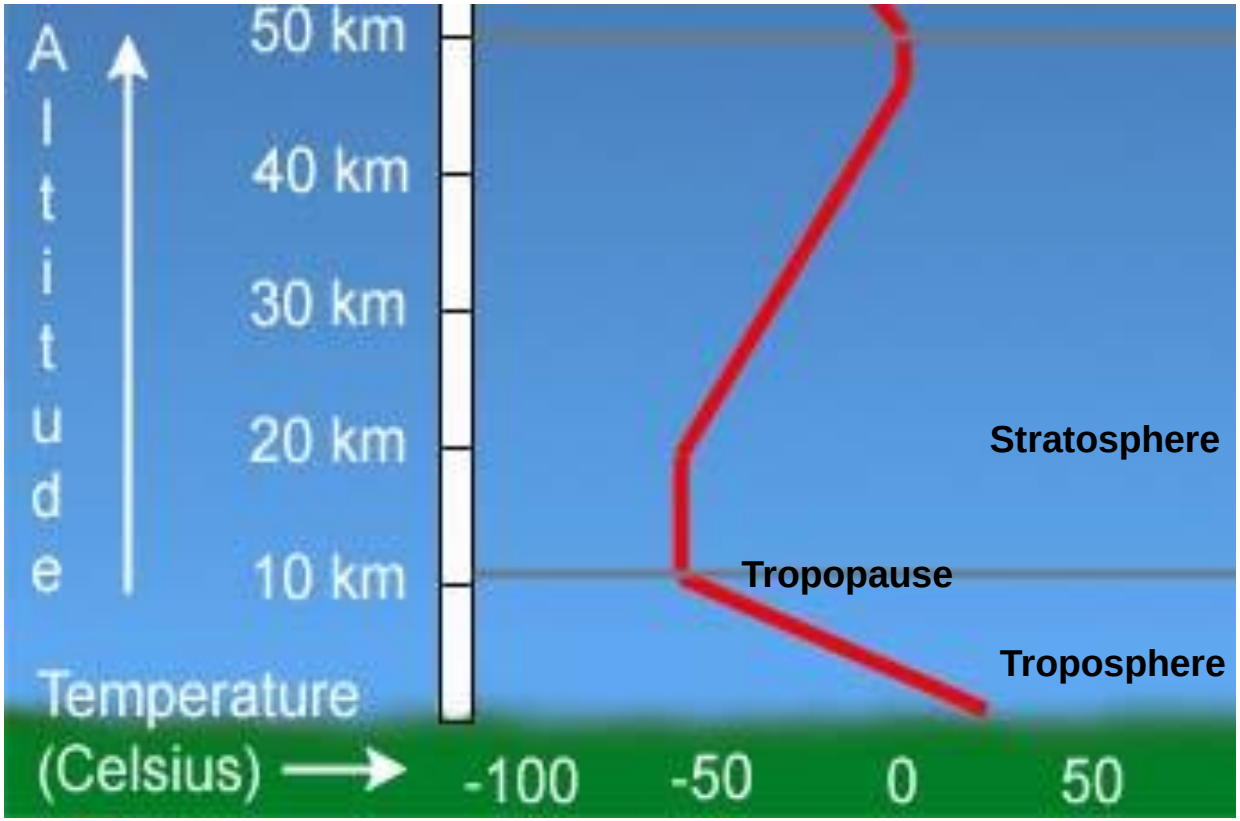
Particlelarly Interesting Science: the Meaning, Marvels and Mysteries of Pyrocumulonimbus

Outline

- The Texbook
- The pyroCb discovery
- The peculiar facts of the pyroCb

The Textbook View

Only volcanic eruptions can inject material into the stratosphere.



The Textbook View

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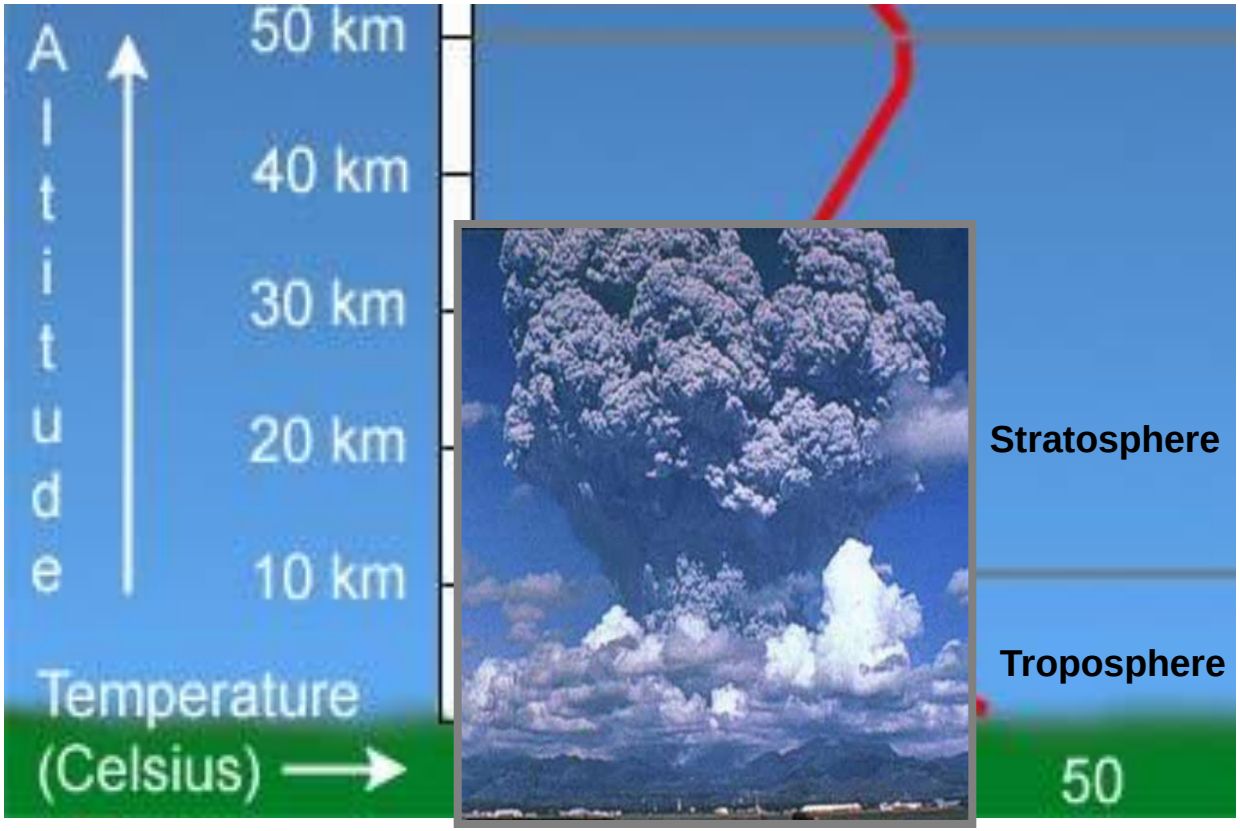

The Textbook View

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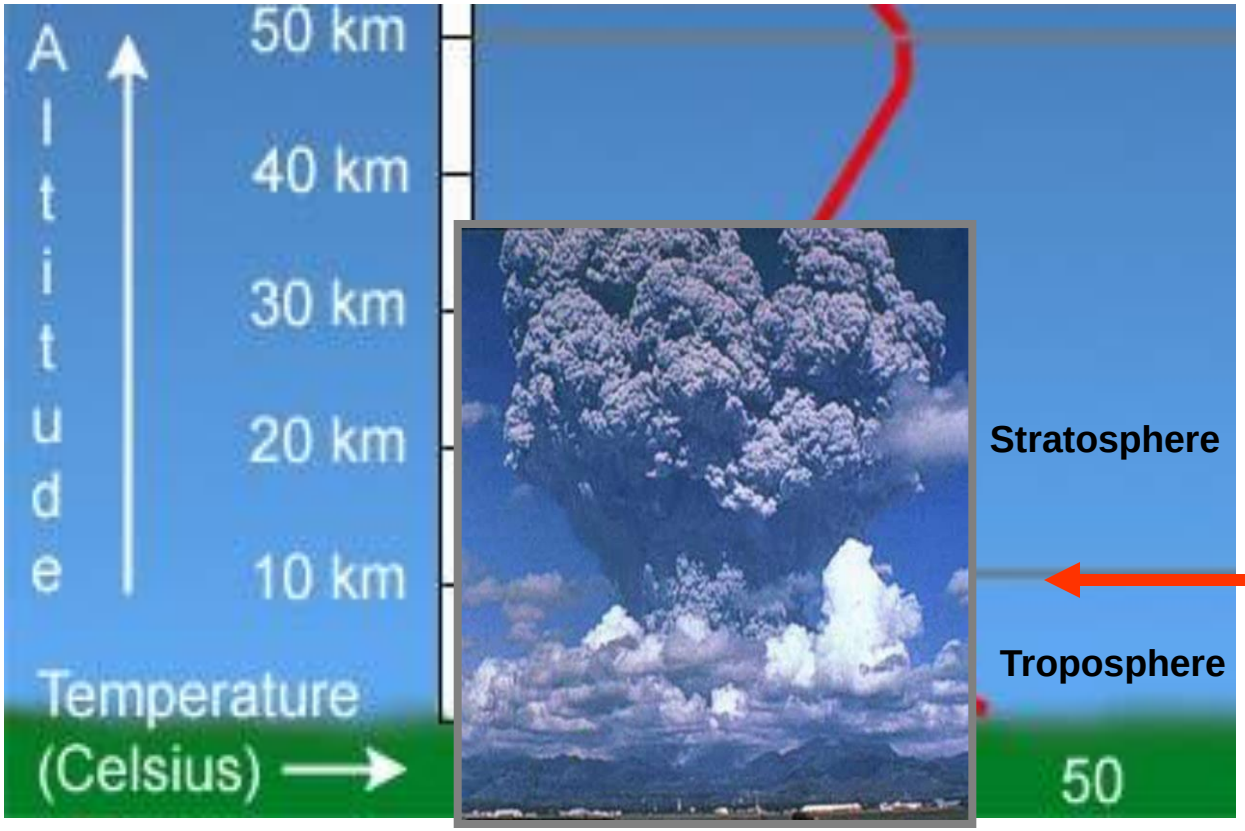
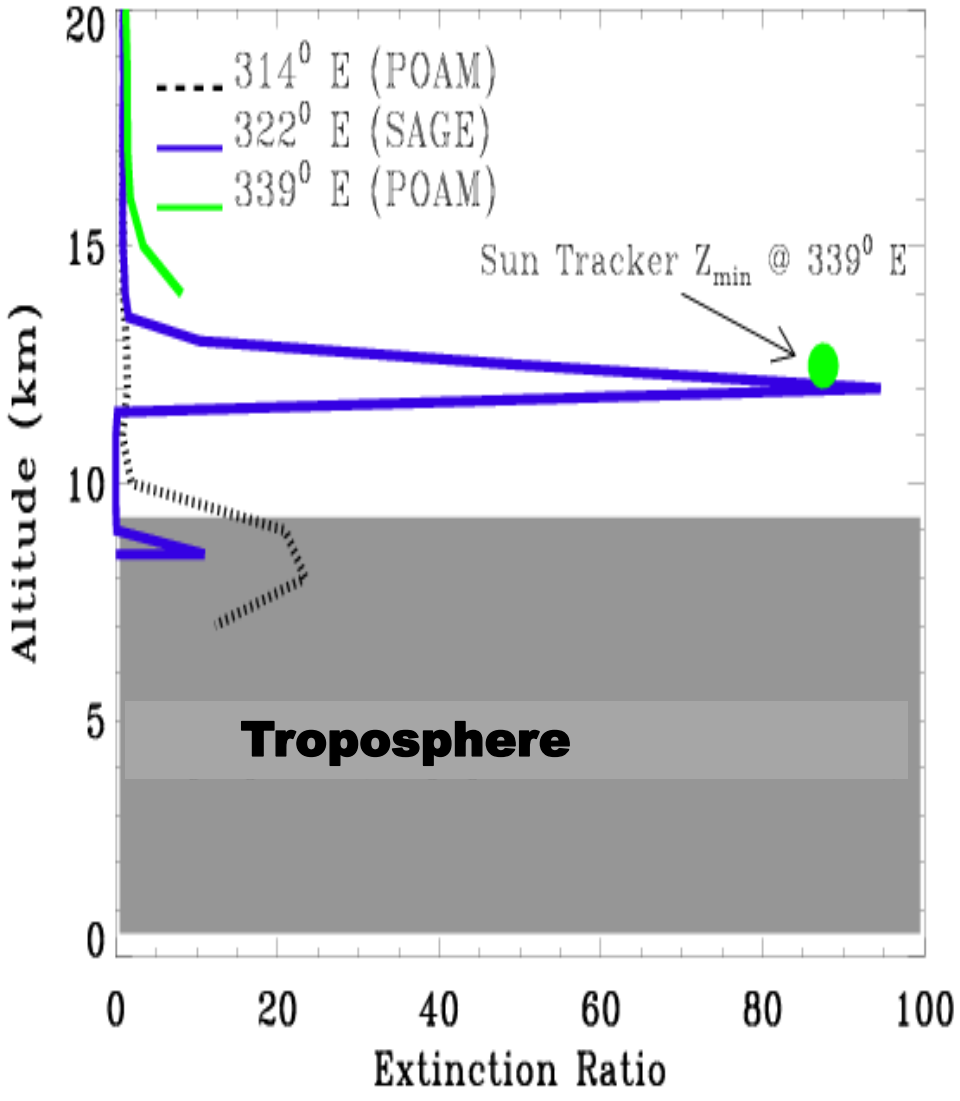


Thunderstorms: capped by Tropopause Barrier

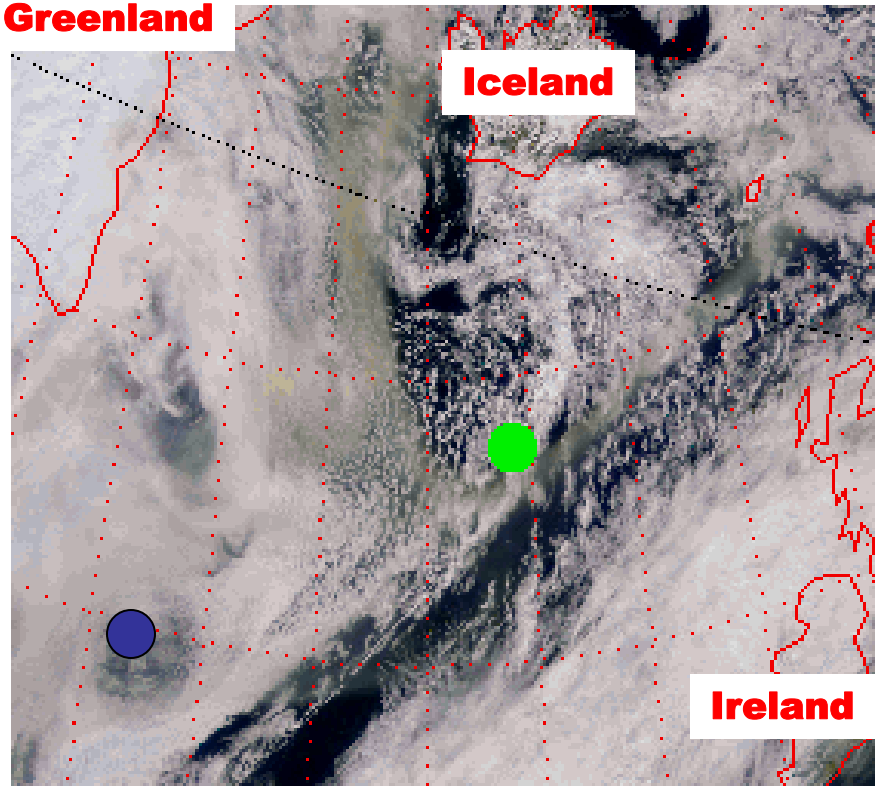
Stratospheric Smoke Layer

7 August 1998 smoke plume over North Atlantic

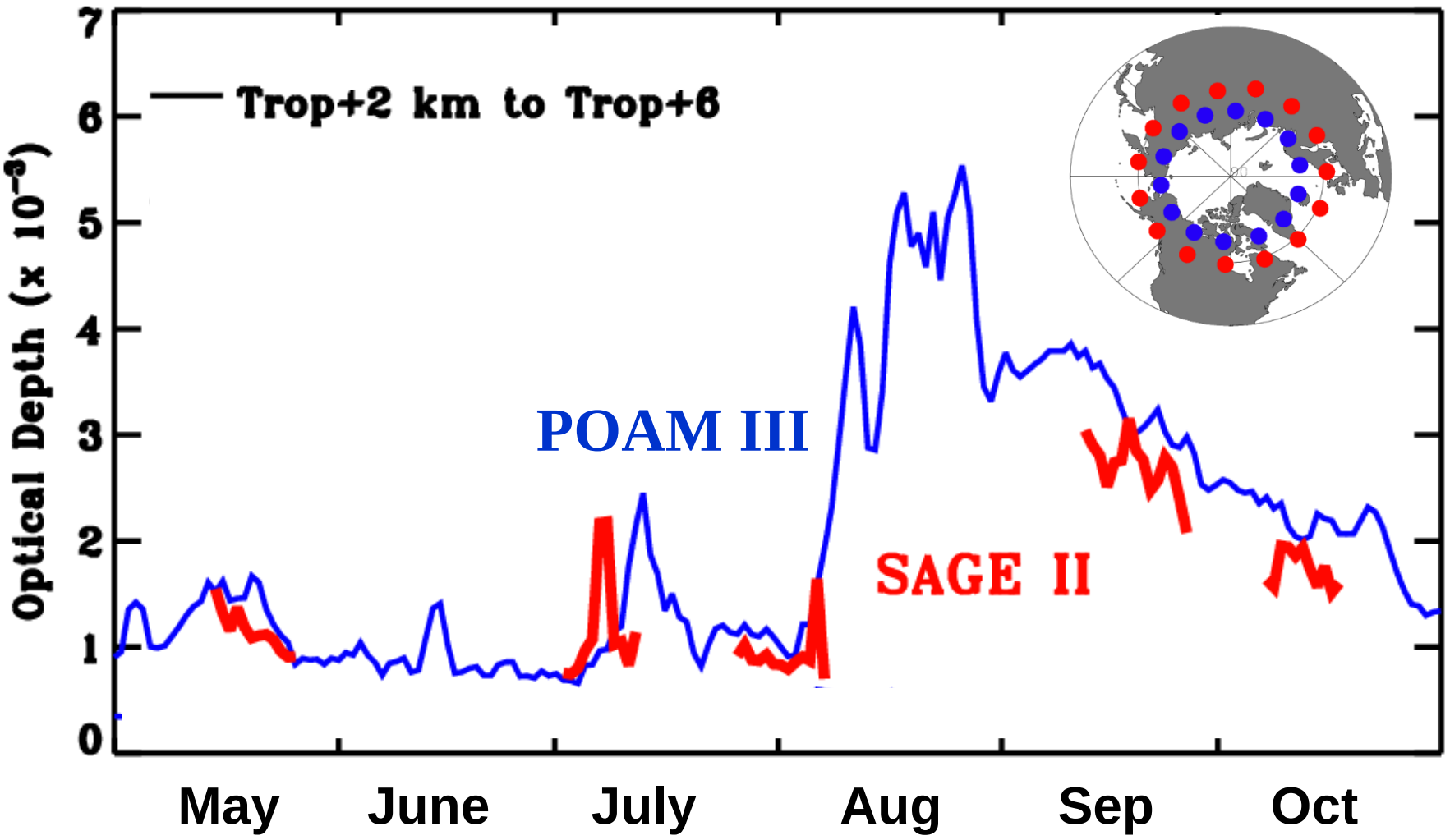
(Fromm et al., JGR, 2005)



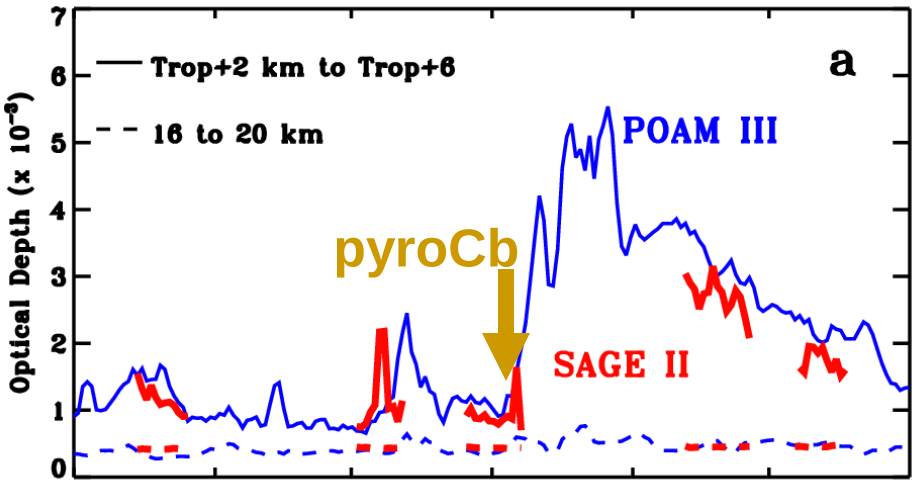
True Color (NASA SeaWiFS)

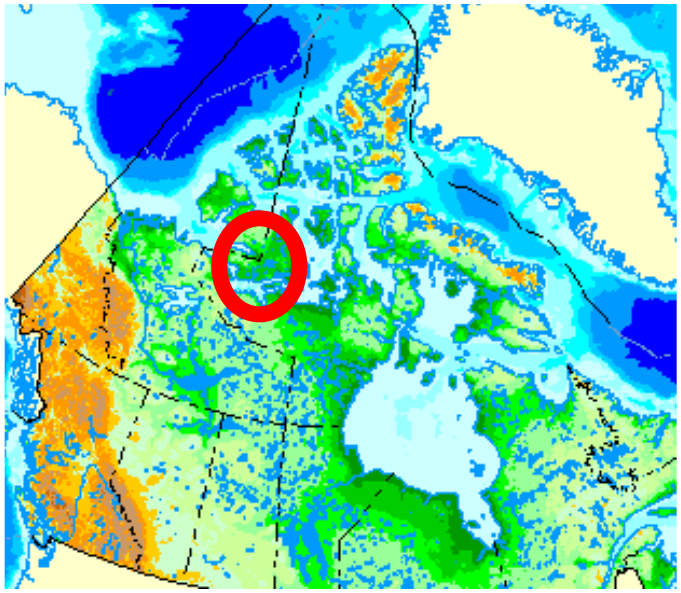


The Amazing Fire Season of 1998 (Fromm et al., 2000, GRL)

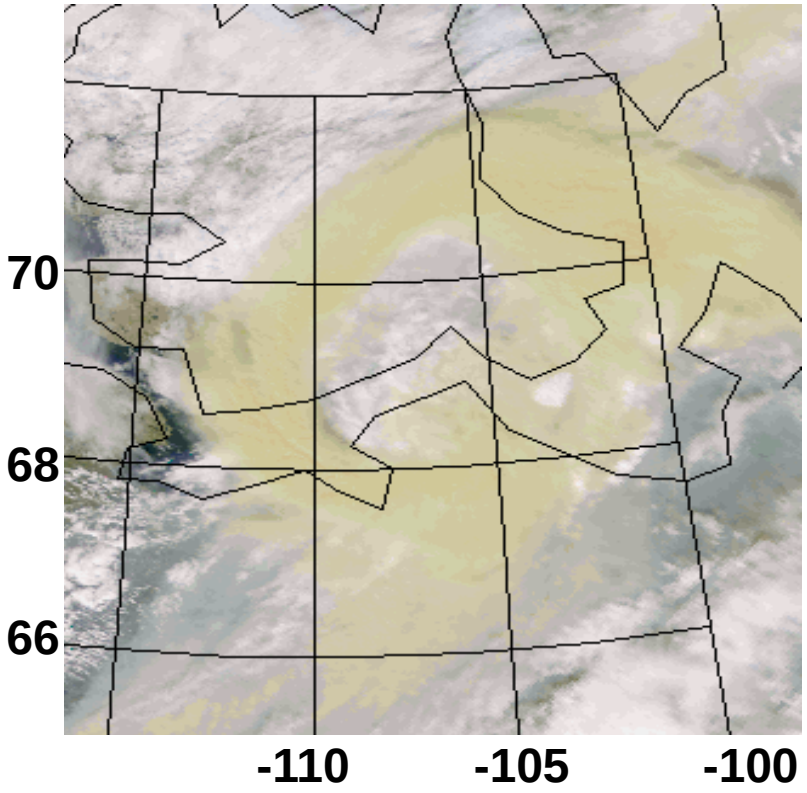


Norman Wells PyroCb Plume
Northern Canada



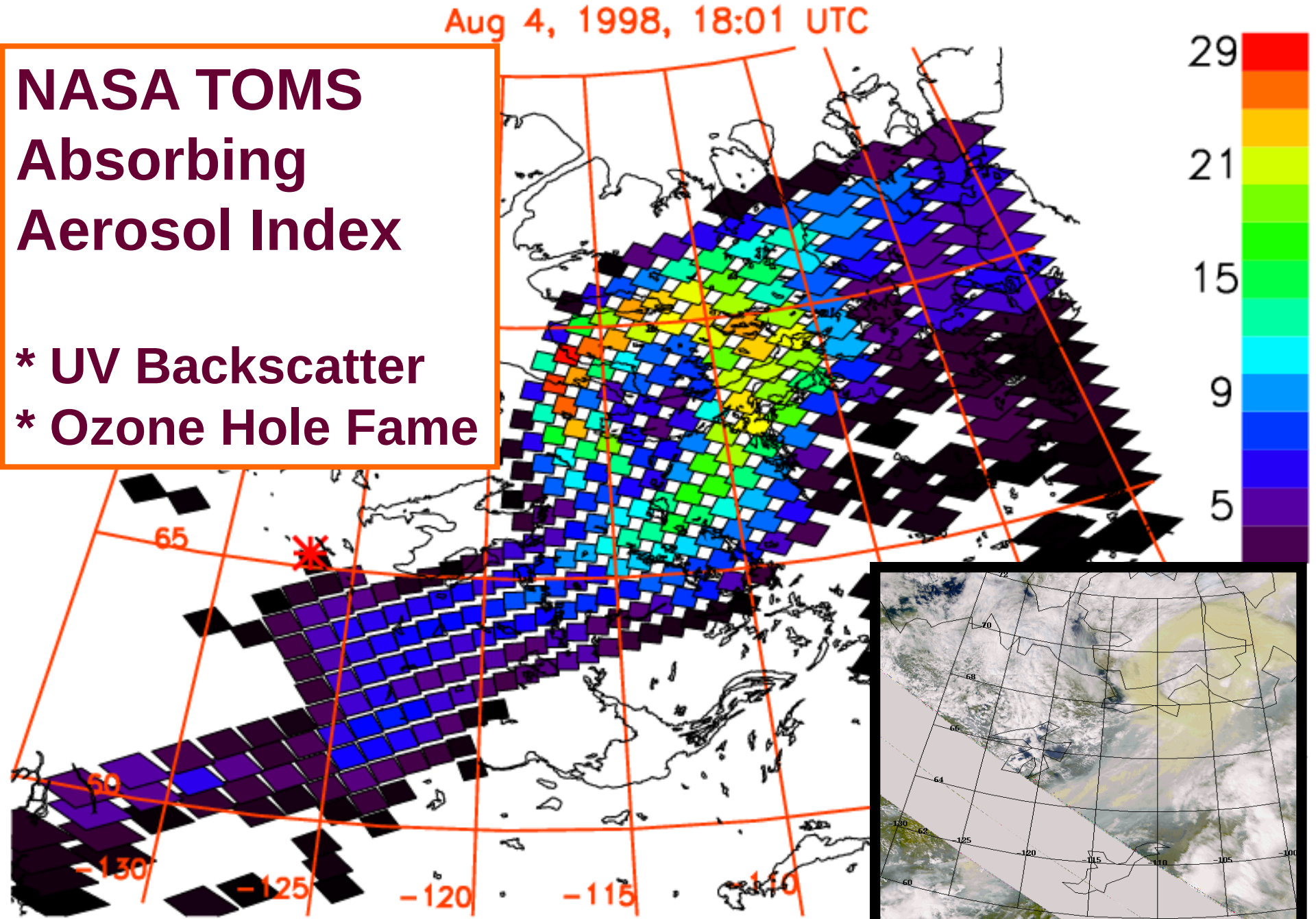


SeaWiFS True Color
4 August 1998
Local Noon



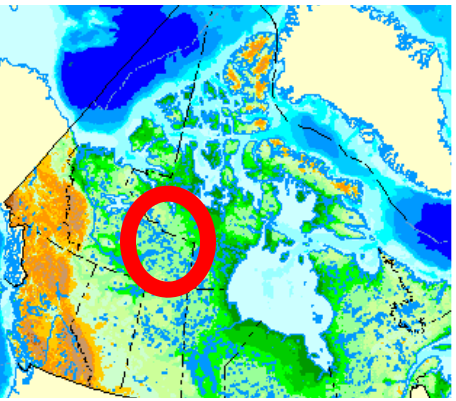
NASA TOMS Absorbing Aerosol Index

* UV Backscatter
* Ozone Hole Fame



Our “Second” PyroCb Plume

29 May 2001, Northwest Territories



TOMS Aerosol Index

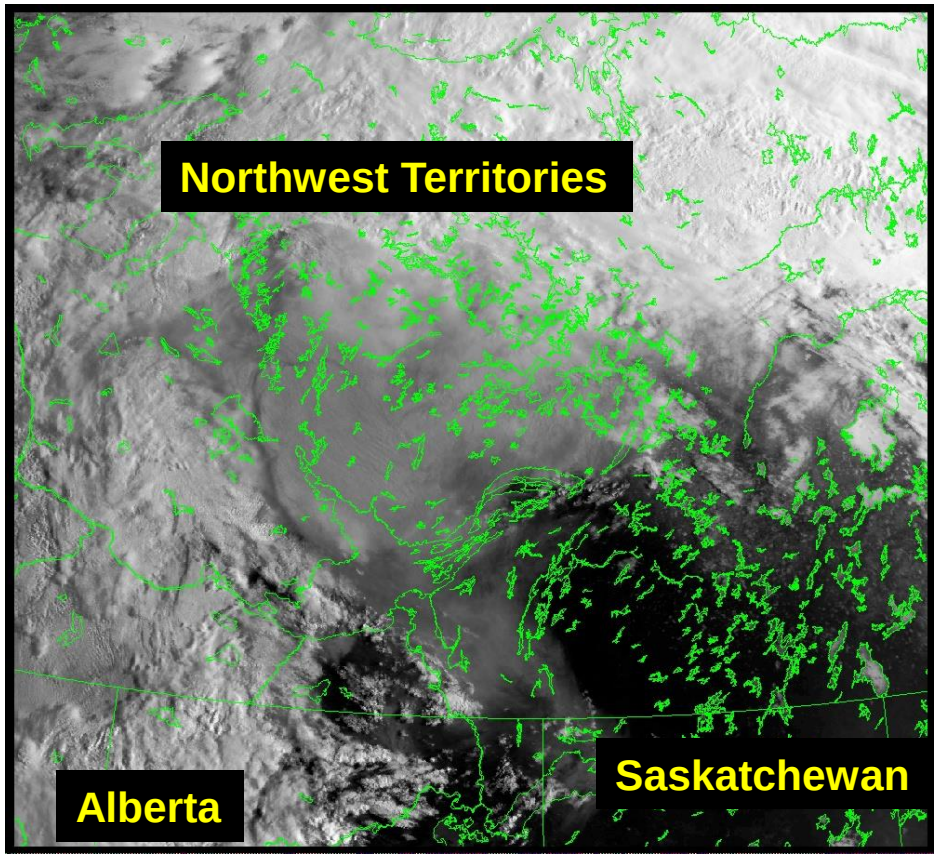
Puzzling PyroCb Plume

NOAA/AVHRR
1349 UTC
29 May 2001

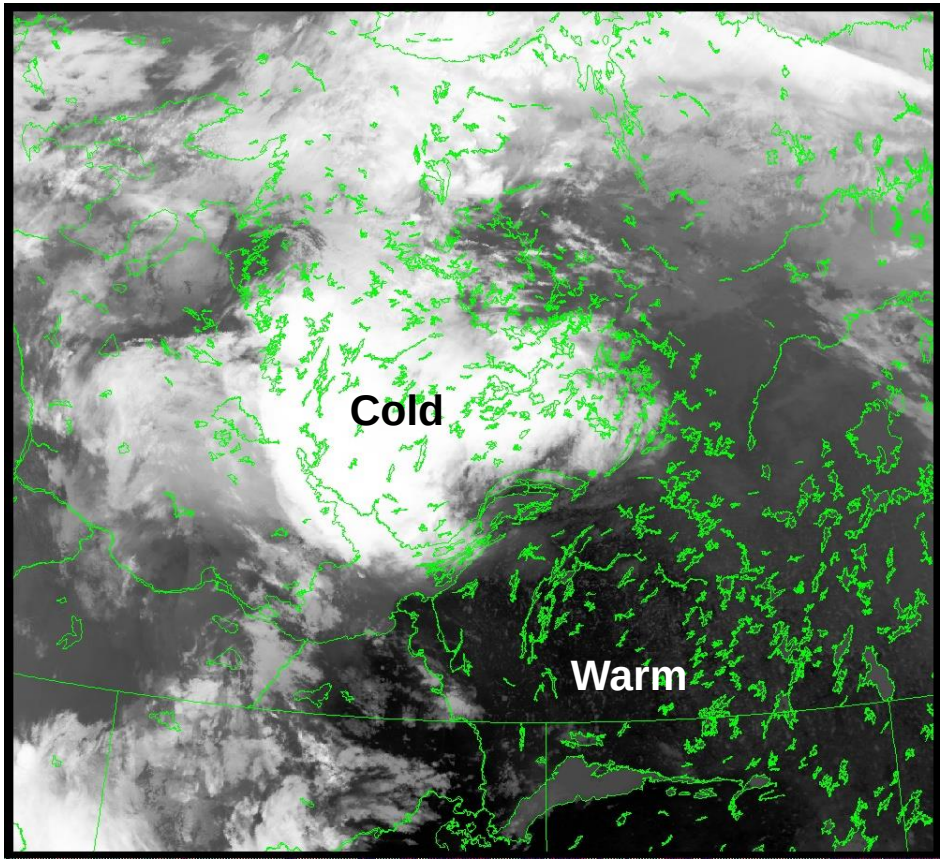
Ashen Gray! Yet VERY cold!!

Where did it come from?!?

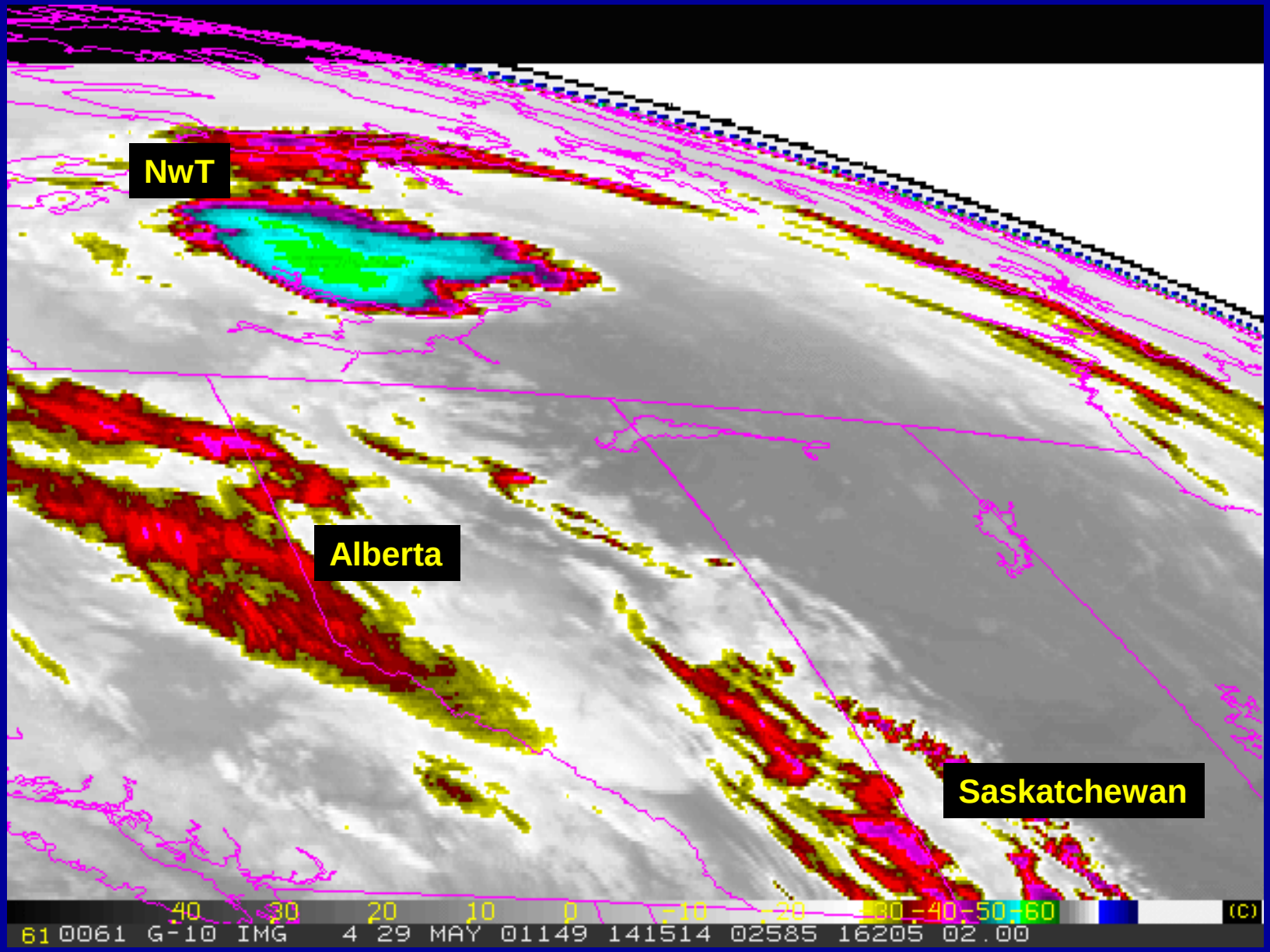
Vis



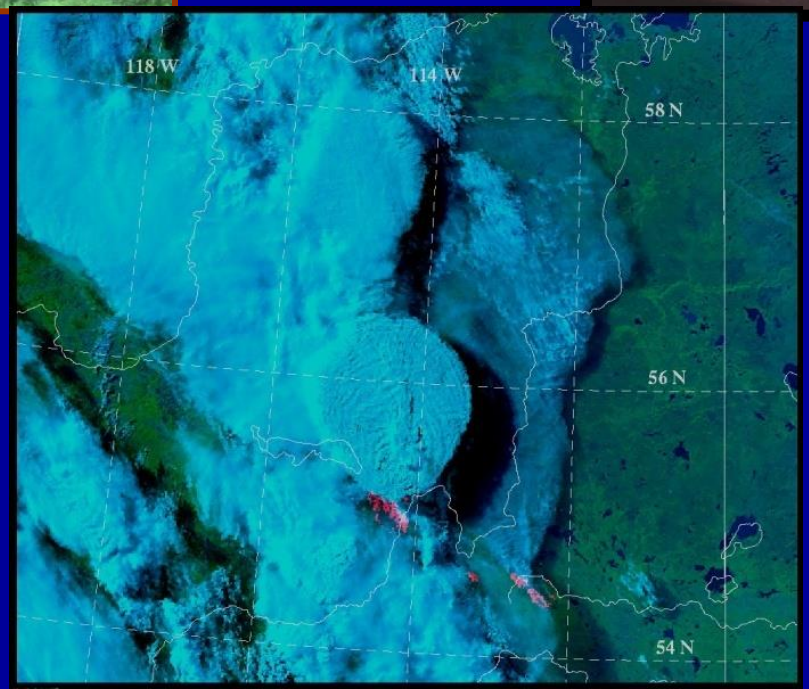
IR



Let's follow that weird cloud backward in time with Geostationary IR images!
Where/when it disappears will reveal ground zero.

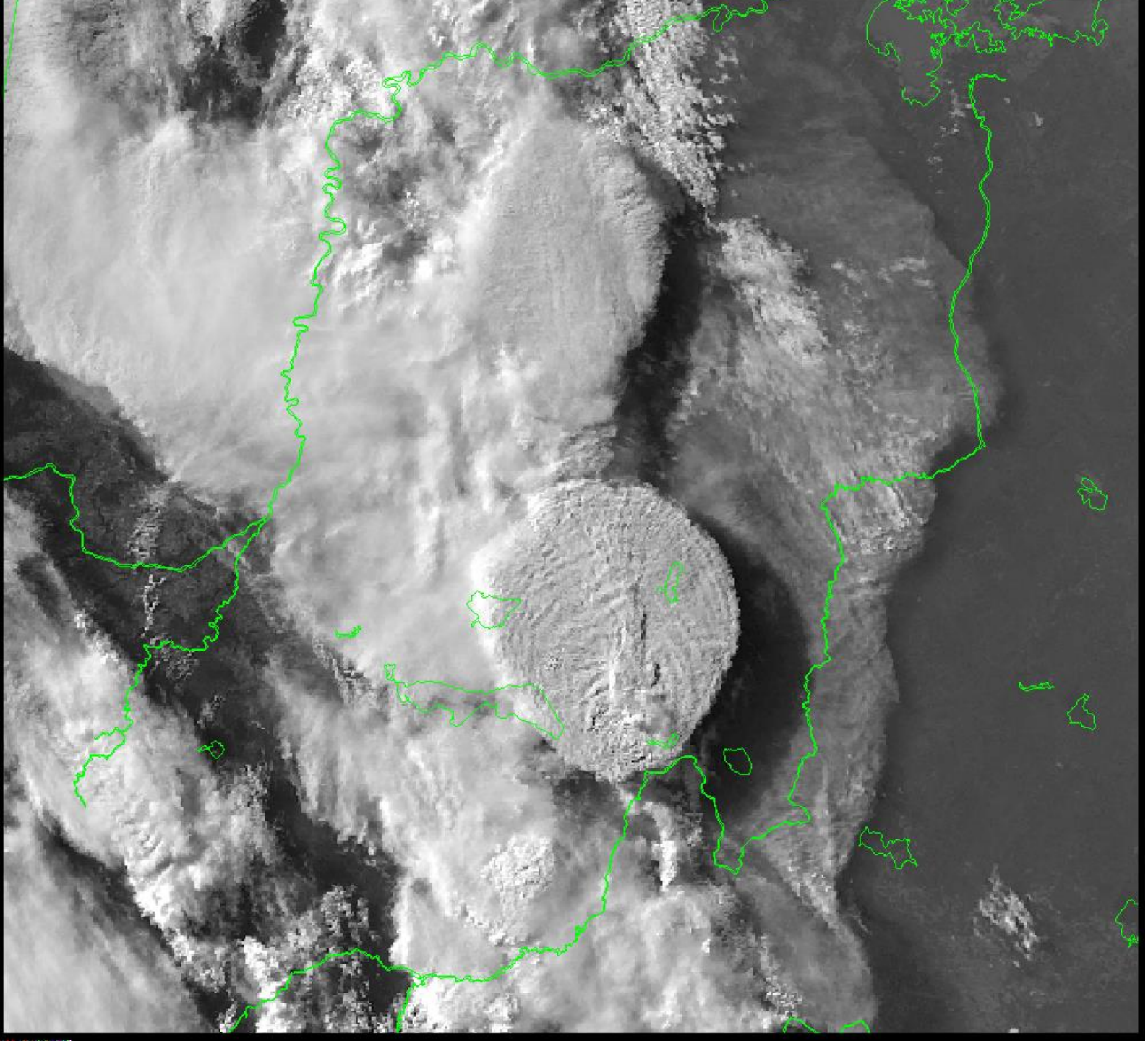


The Chisholm (Alberta) pyroCb "Eruption" of 28 May 2001—Fire, Thunderstorm, & Stratospheric Smoke



AVHRR
0221 UTC
29 May 2001

RGB: Channel 3, 2, 1

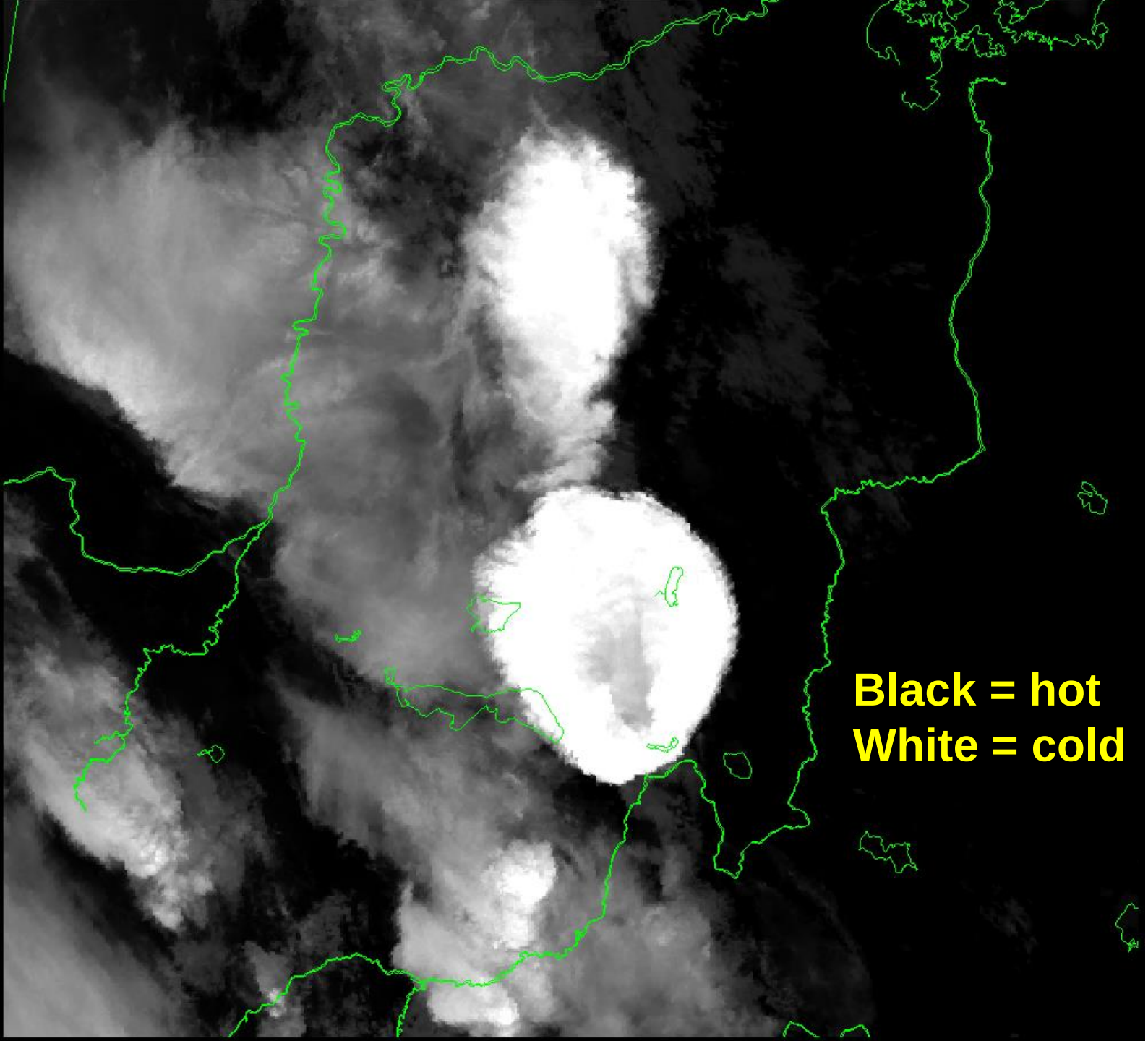


Chisholm PyroCb

29 May 2001

0221 UTC

AVHRR vis (ch 1)

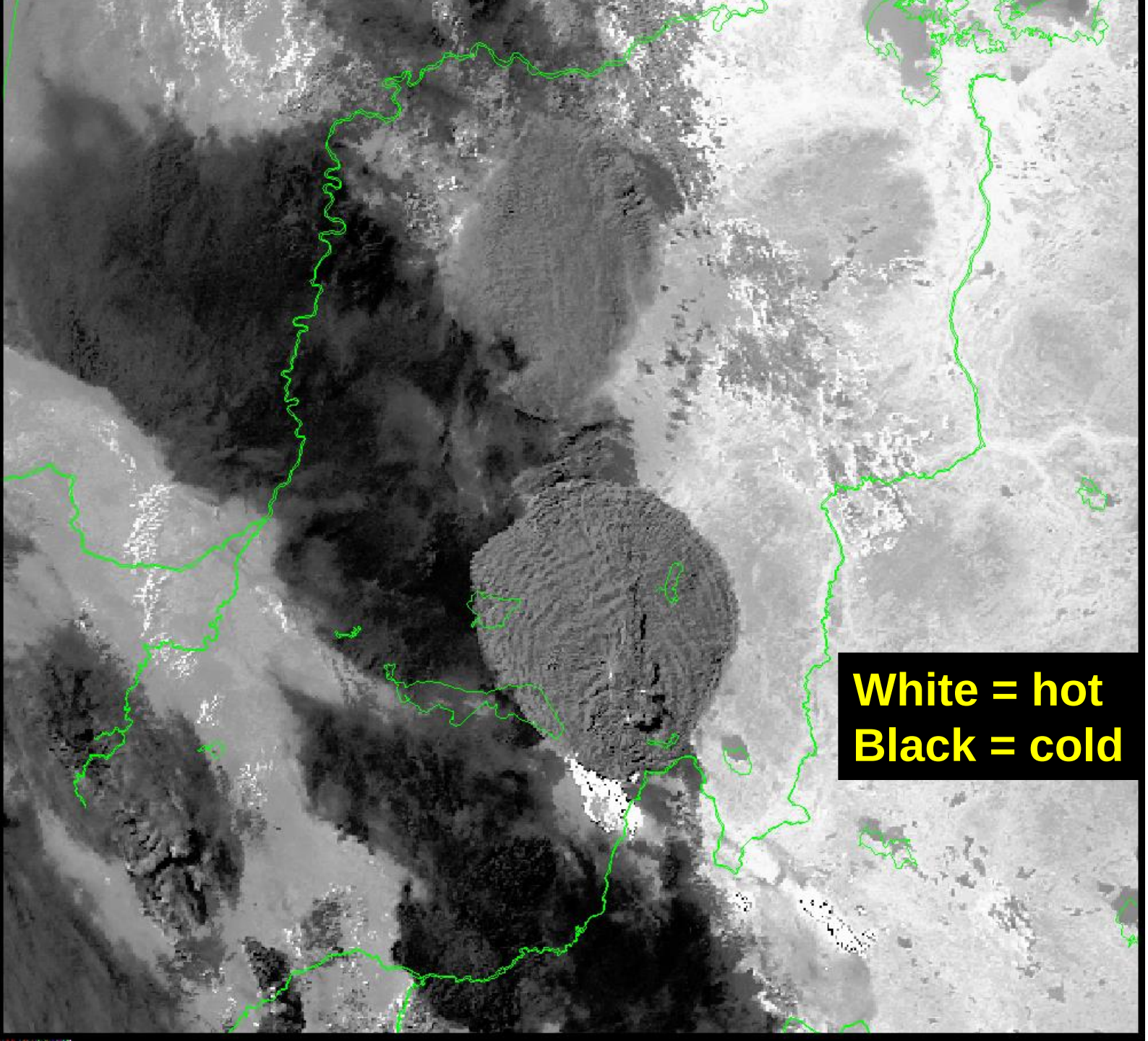


Chisholm PyroCb

29 May 2001

0221 UTC

AVHRR Channel 4 11µm BT



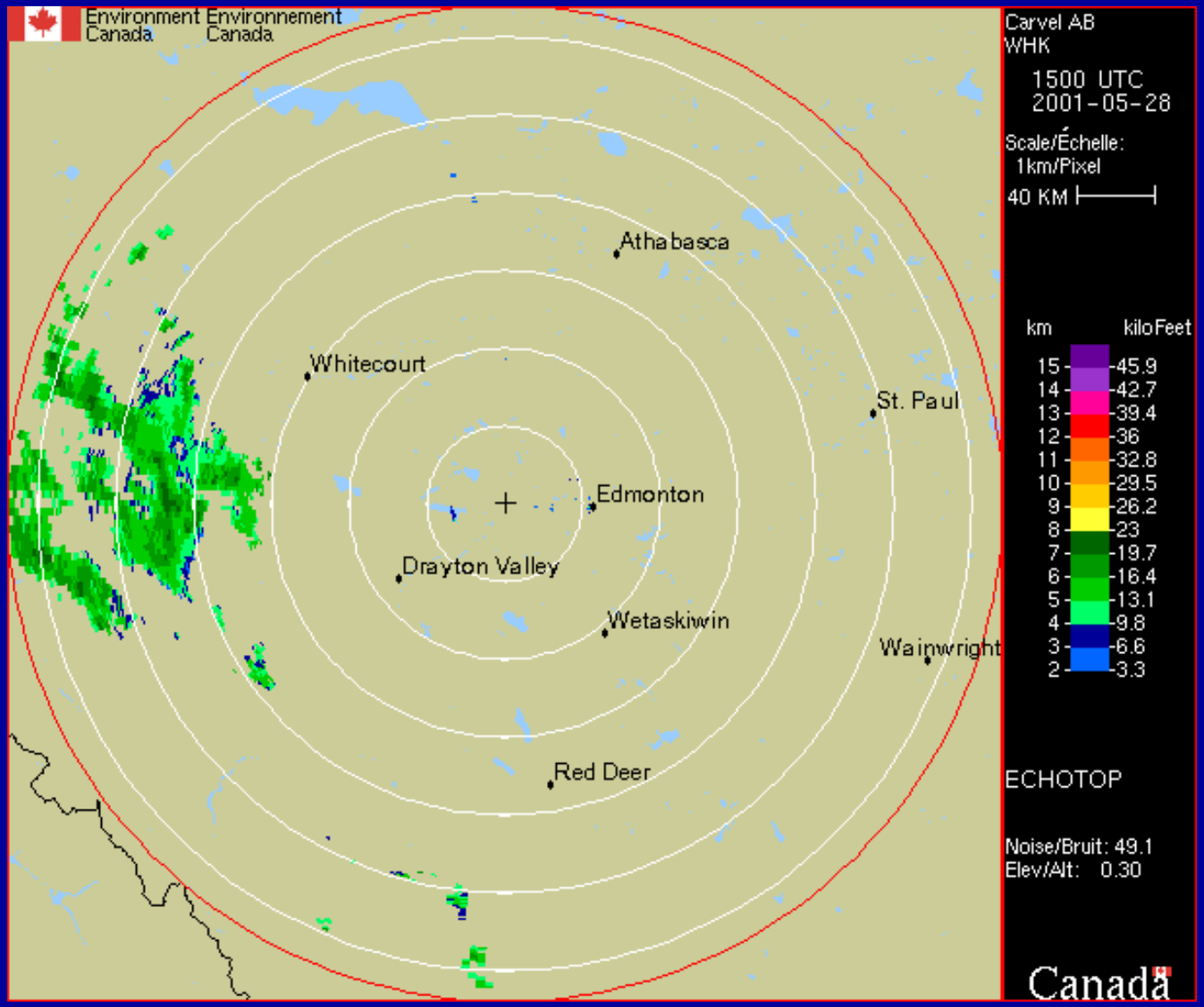
Chisholm
PyroCb

29 May 2001

0221 UTC

AVHRR
Channel 3
3.7 μm BT

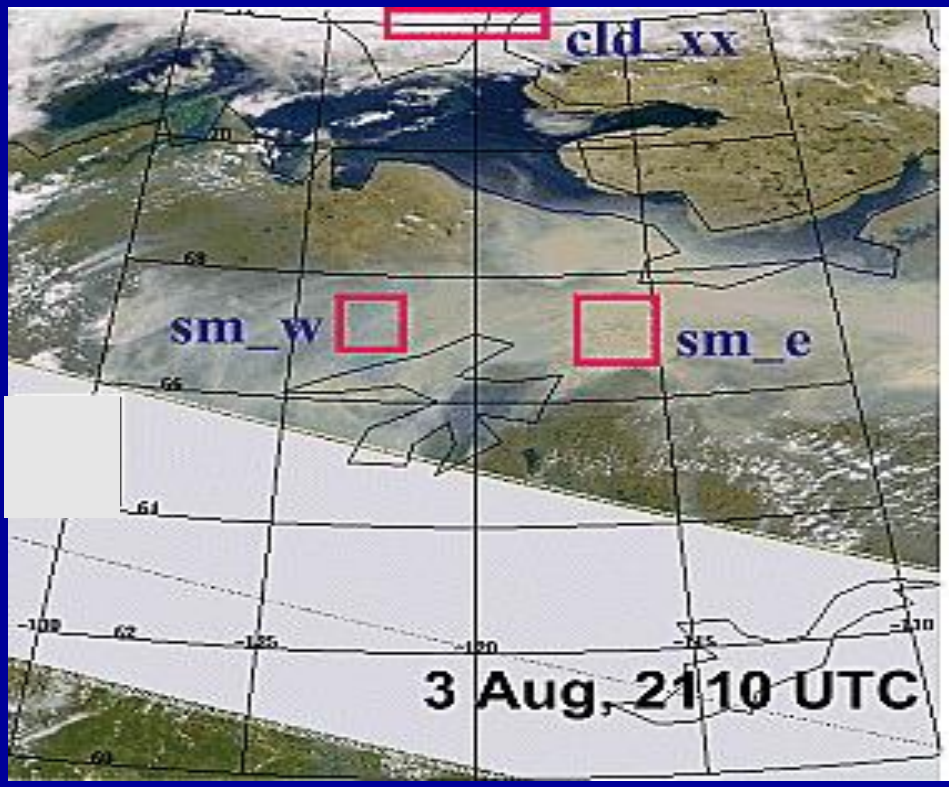
Edmonton, Alberta
Radar Echotops

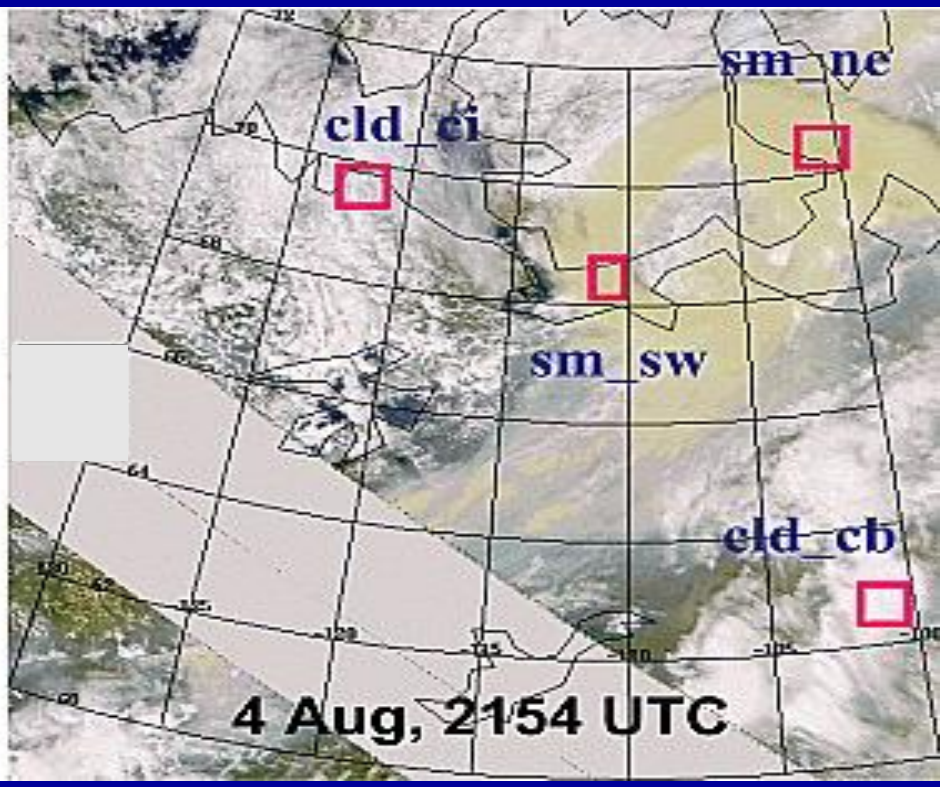


15 UTC 28 May
to
05 UTC 29 May

*** 14 hours**

Color and Texture of PyroCb Smoke

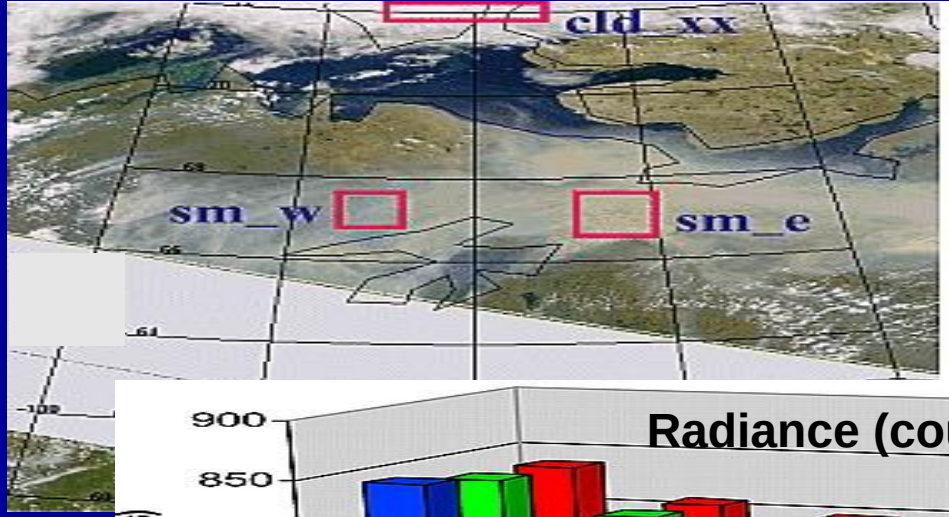


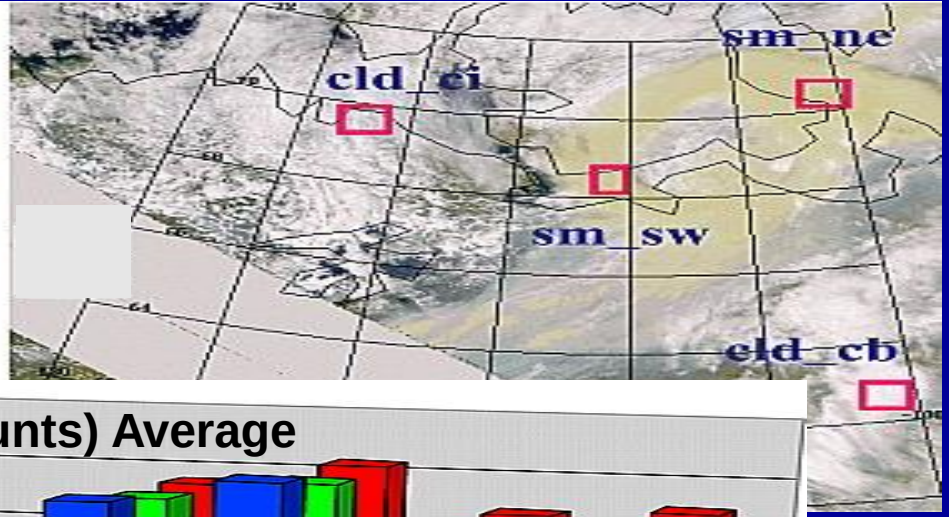


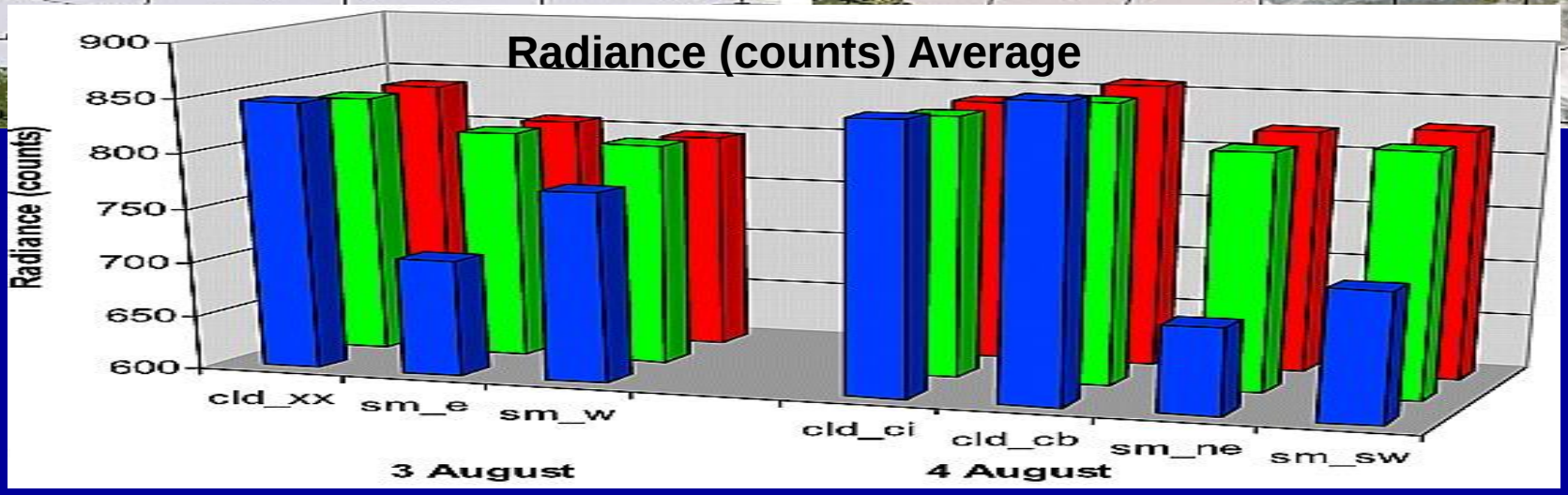
Compare Norman Wells (1998) Stratospheric Smoke with

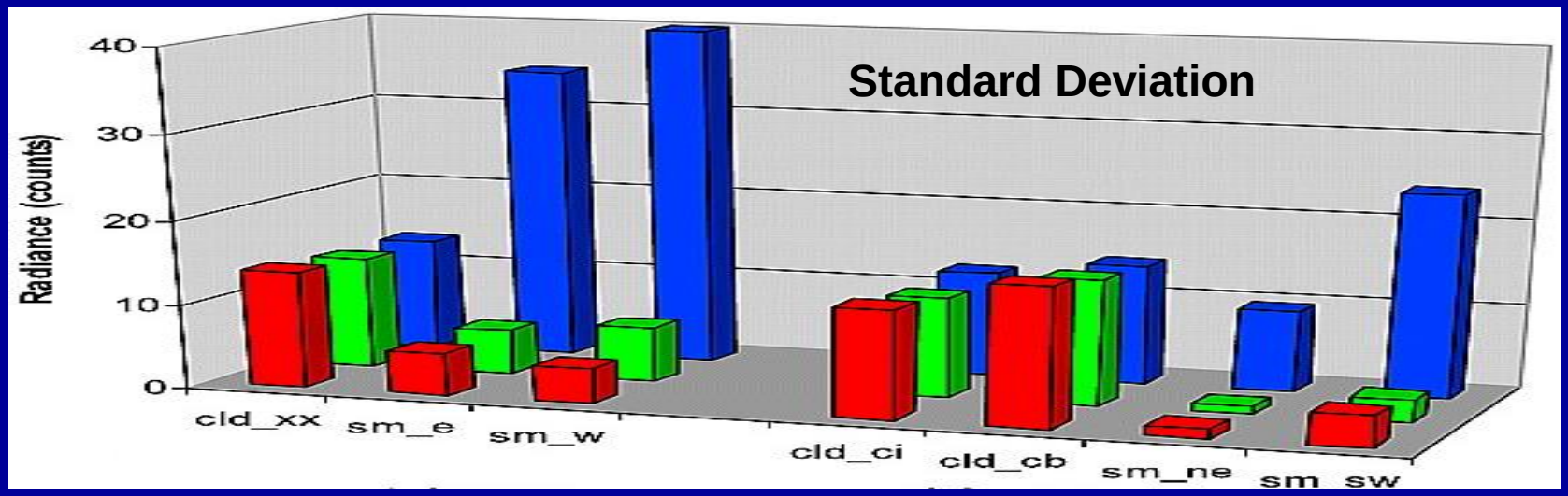
*** pre-pyroCb "dry" smoke**

*** 3 optically opaque cloud scenes**







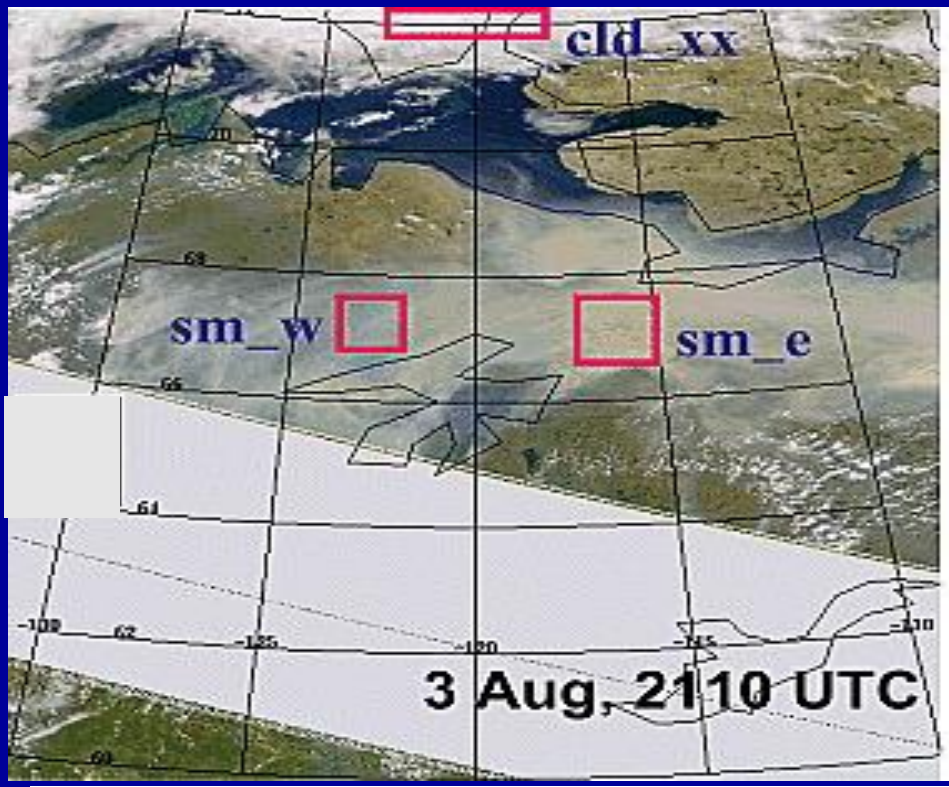


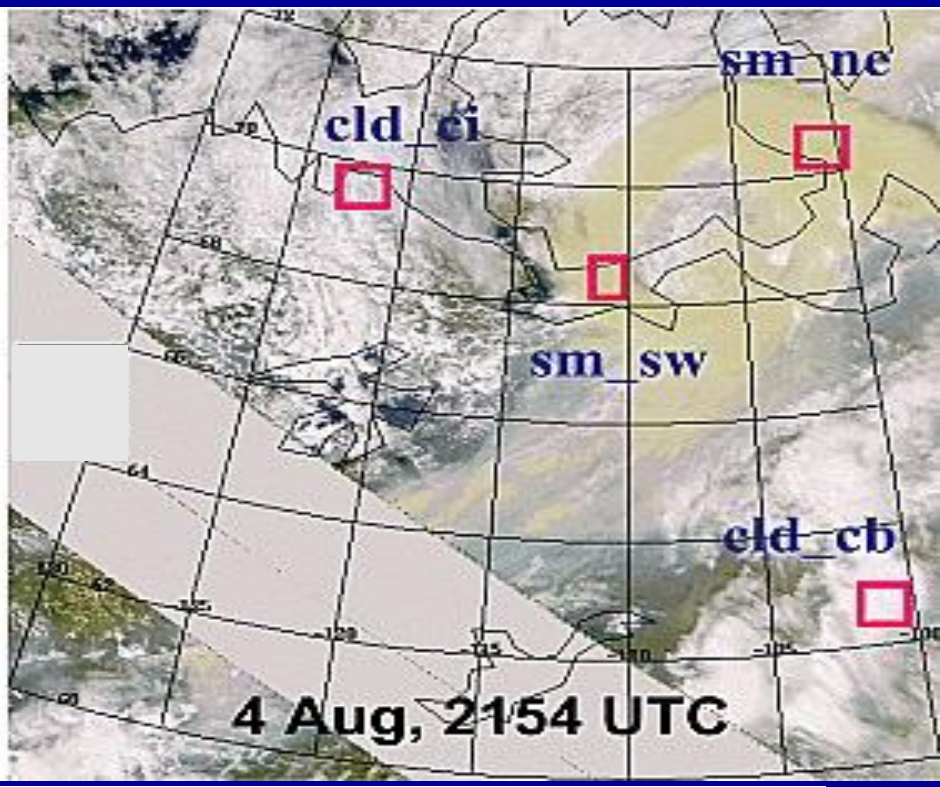
412

555

670 nm

Color and Texture of PyroCb Smoke





*** Color: icy pyroCb smoke is as brown as "dry" smoke!**
!? What are the implications for abundance ?!

*** Texture: stratospheric smoke is uncommonly smooth.**
? Marker of super stable flow regime ?

So you ask:

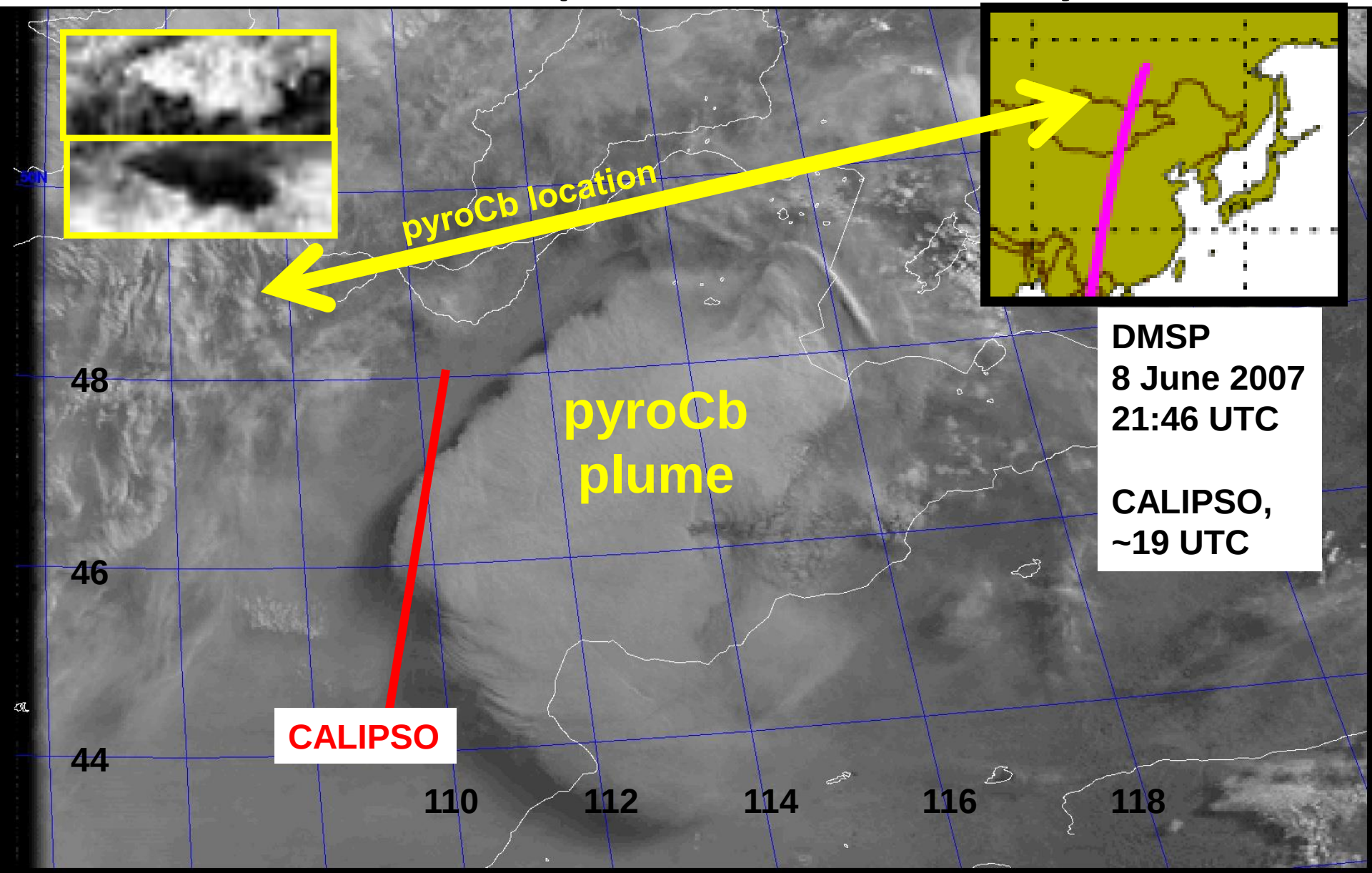
Does a pyroCb *REALLY* inject emissions *DIRECTLY* to the stratosphere?

Let's find out.

There was a pyroCb in Mongolia 9 years ago…

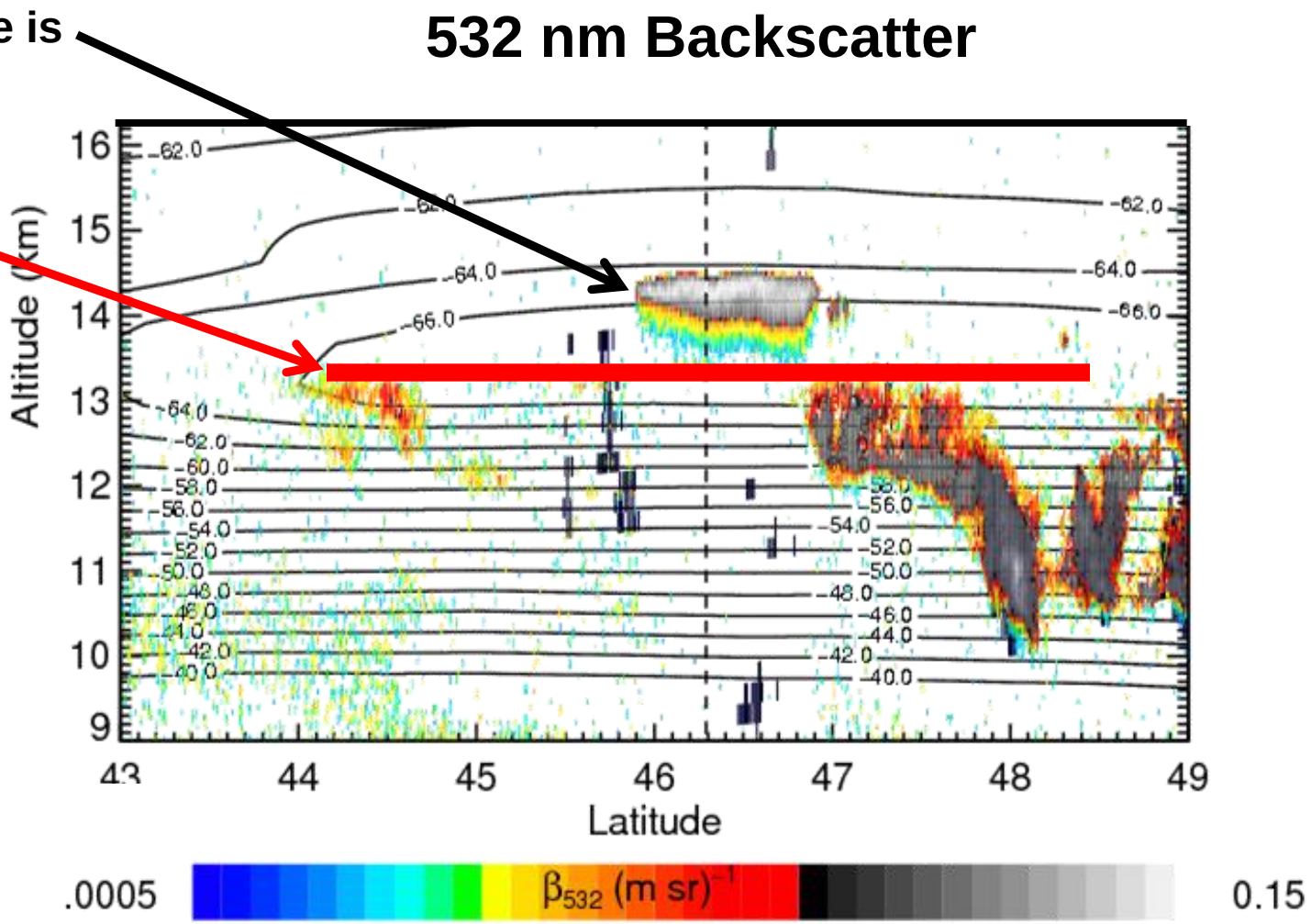
Mongolia pyroCb popped in late afternoon, 8 June 2007

DMSP Visible, post-dawn the next day



CALIPSO nips the edge of the plume!

Smoke plume is above **coldpoint! (red line)**

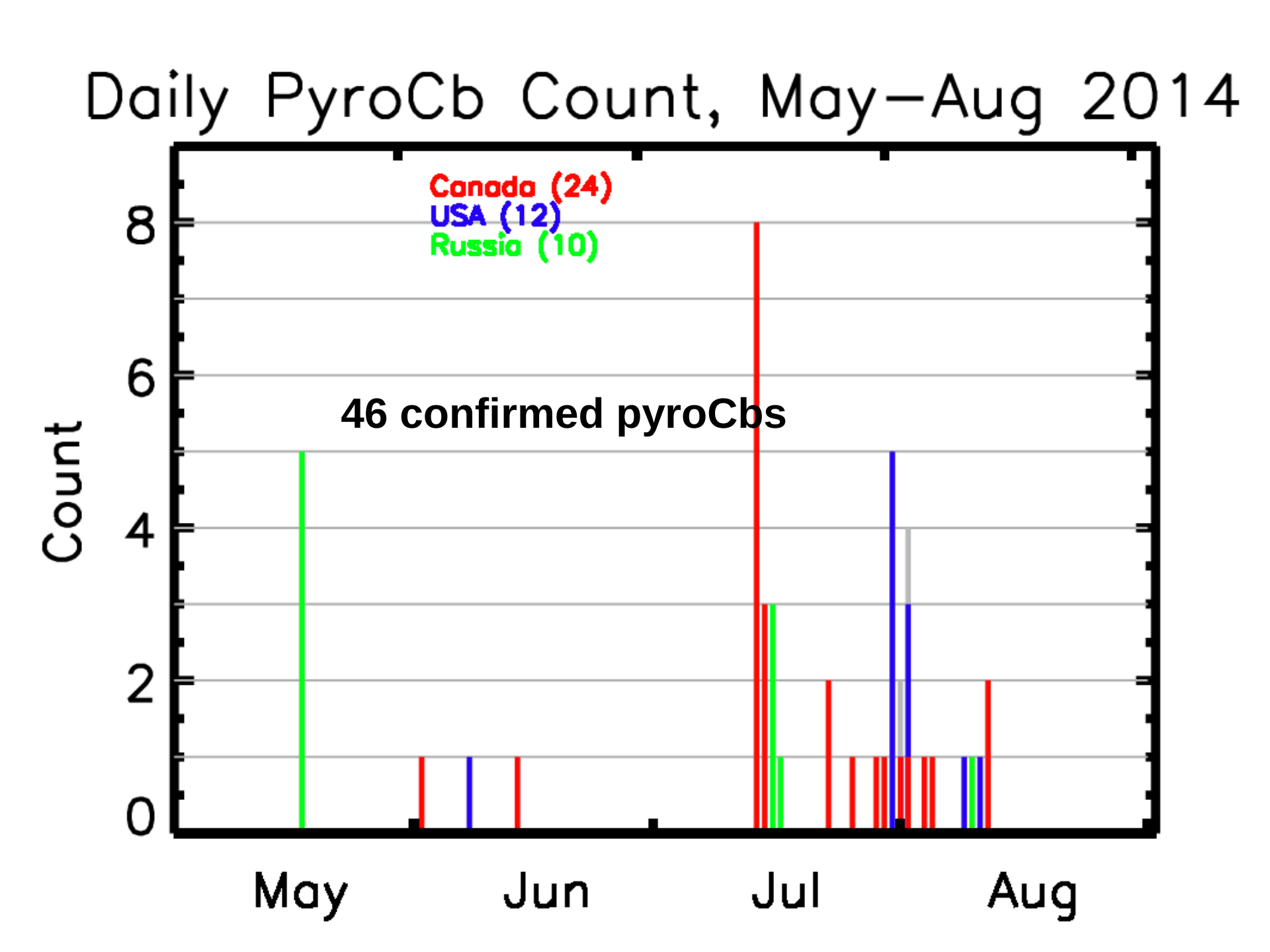


Concluding thoughts…

* PyroCb pathway to stratosphere updates the textbook.

* Satellite remote sensing is crucial to our understanding.
* " " " continues to challenge us.

* How important is the pyroCb pathway? TBD


Daily PyroCb Count, May–Aug 2014
Canada (24)
USA (12)
Russia (10)
46 confirmed pyroCbs
Count
0
2
4
6
8
May
Jun
Jul
Aug