

Climatic Consequences of Nuclear War

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Illustration by Jon Lomborg

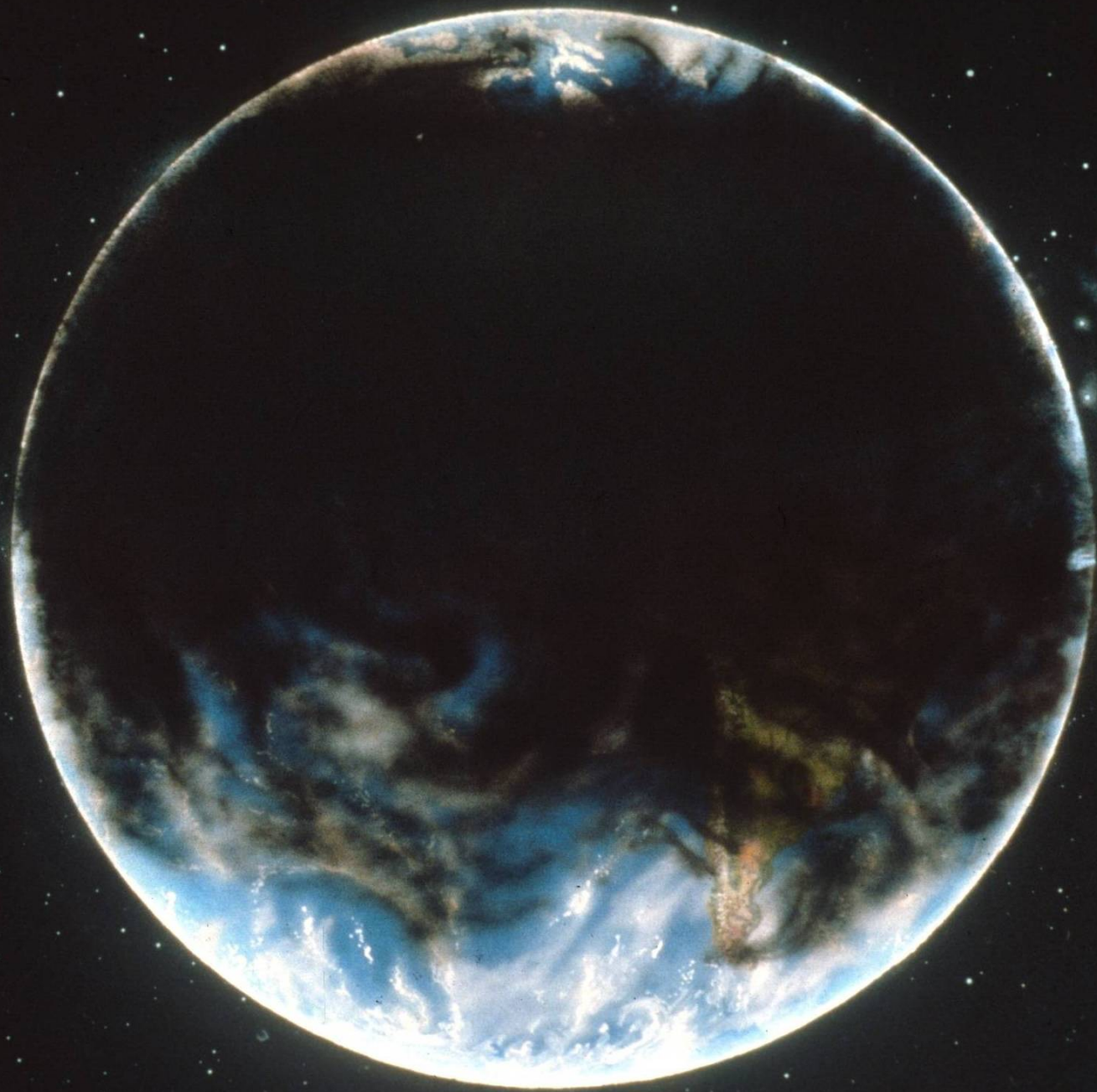


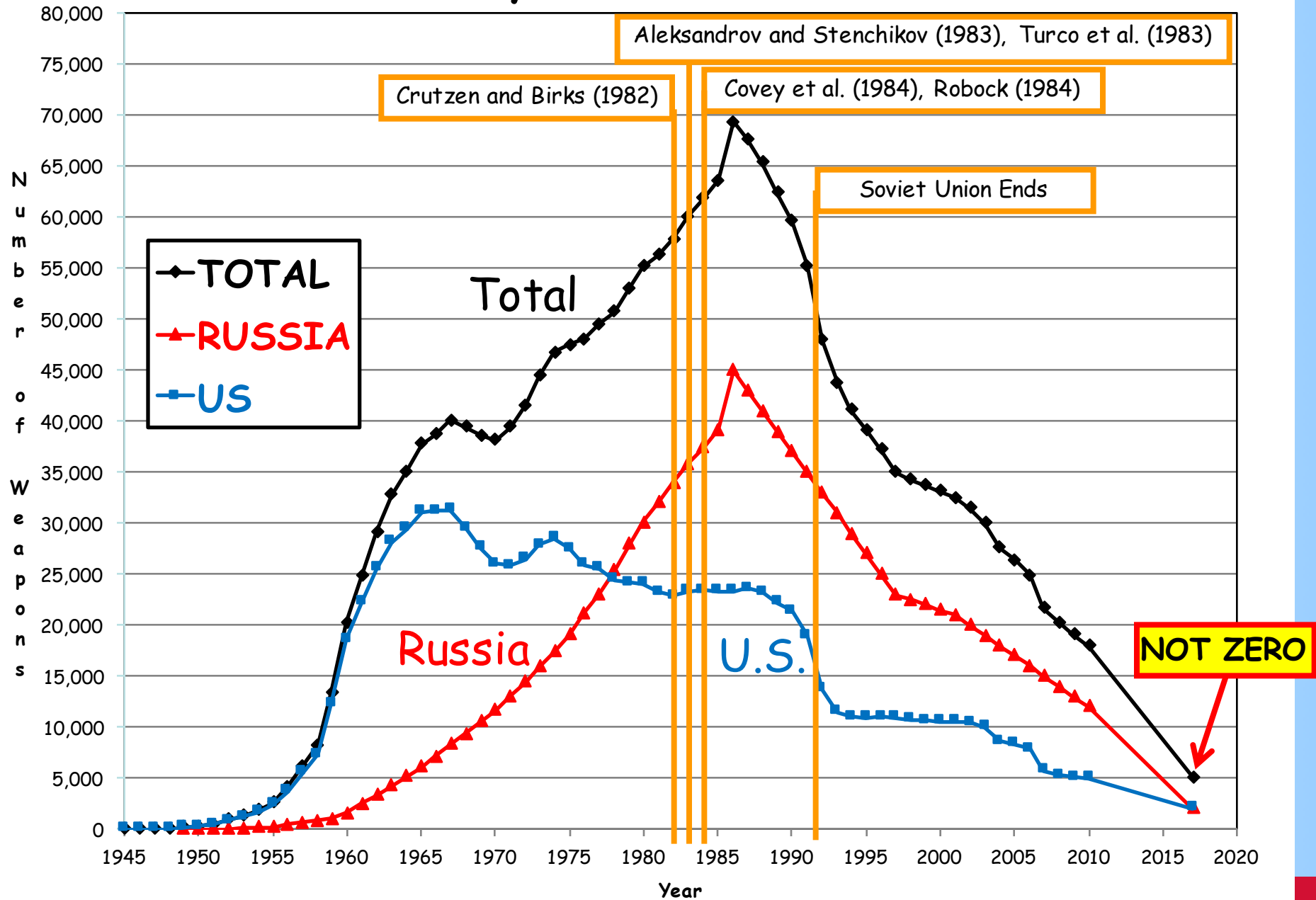
Illustration by Jon Lomborg



Nuclear Winter

Cold, Dry, Dark, and More UV
Crops Dying and Global Famine

History of Nuclear Warheads



Ronald Reagan:

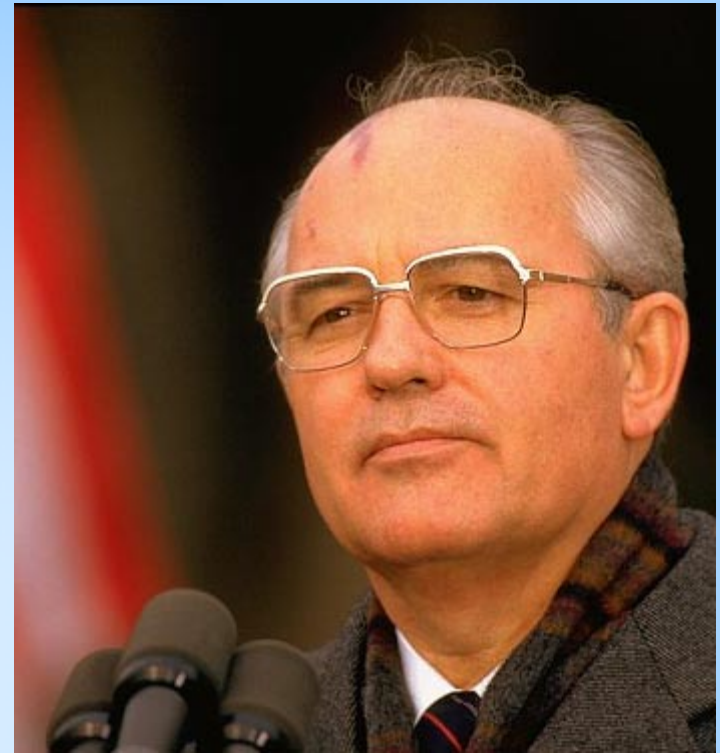
When asked about the effects of nuclear war in a February 12, 1985 interview in the *New York Times* said,



"A great many reputable scientists are telling us that such a war could just end up in no victory for anyone because we would wipe out the earth as we know it. And if you think back to ... natural calamities - back in the last century, in the 1800's, ... volcanoes - we saw the weather so changed that there was snow in July in many temperate countries. And they called it the year in which there was no summer. Now if one volcano can do that, what are we talking about with the whole nuclear exchange, the nuclear winter that scientists have been talking about? It's possible ..."

Mikhail Gorbachev:

“Mikhail Gorbachev explains
what's rotten in Russia”
by Mark Hertsgaard
Salon.com, Sept. 7, 2000



“Models made by Russian and American scientists showed that a nuclear war would result in a nuclear winter that would be extremely destructive to all life on Earth; the knowledge of that was a great stimulus to us, to people of honor and morality, to act in that situation.”

THE STORY OF AN EYEWITNESS

By Jack London

Collier's, the
National Weekly

May 5, 1906

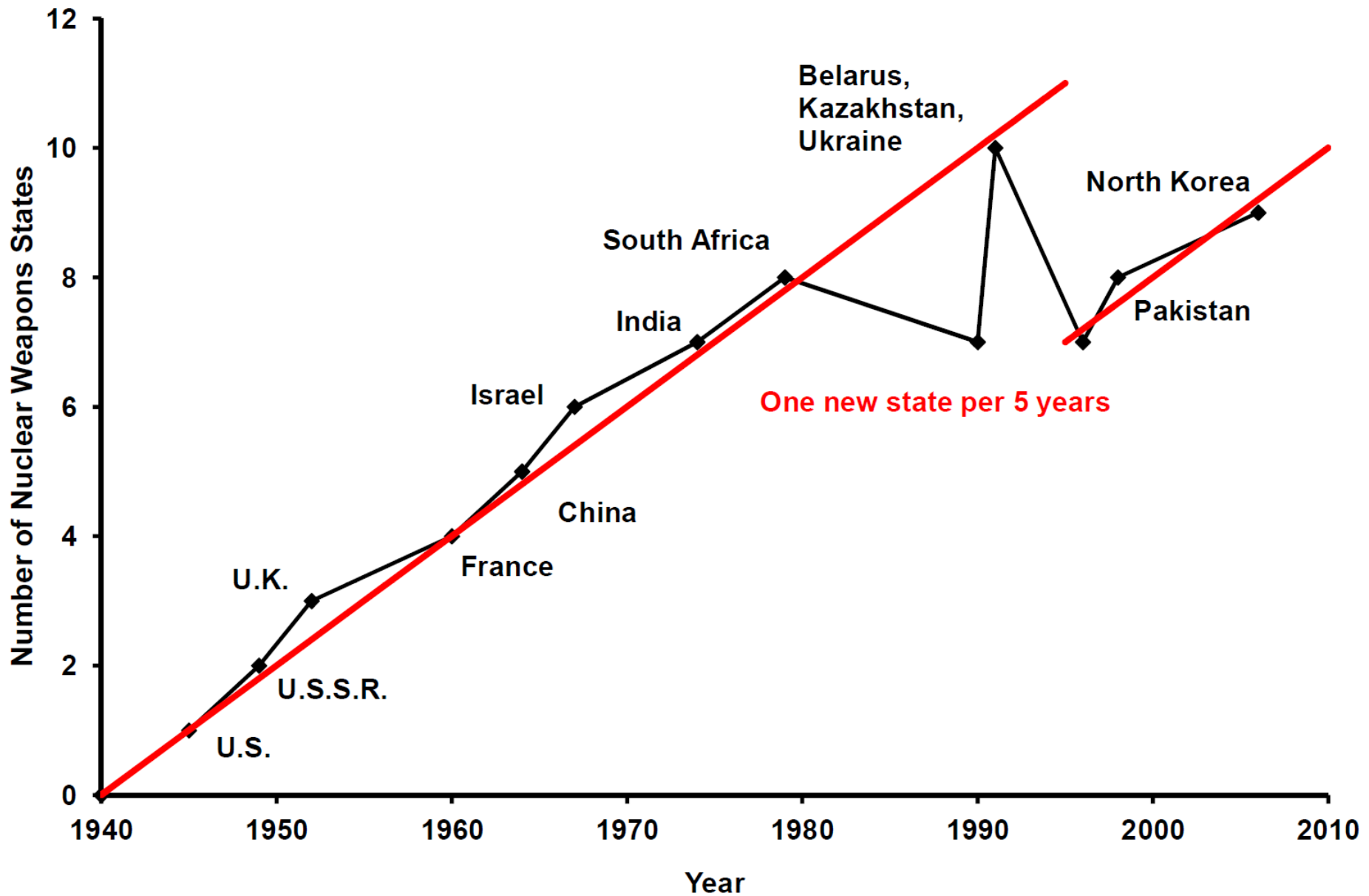


Within an hour after the earthquake shock the smoke of San Francisco's burning was a lurid tower visible a hundred miles away. And for three days and nights this lurid tower swayed in the sky, reddening the sun, darkening the day, and filling the land with smoke.

... I watched the vast conflagration from out on the bay. It was dead calm. Not a flicker of wind stirred. Yet from every side wind was pouring in upon the doomed city. East, west, north, and south, strong winds were blowing upon the doomed city. The heated air rising made an enormous suck. Thus did the fire of itself build its own colossal chimney through the atmosphere. Day and night this dead calm continued, and yet, near the flames, the wind was often half a gale, so mighty was the suck.

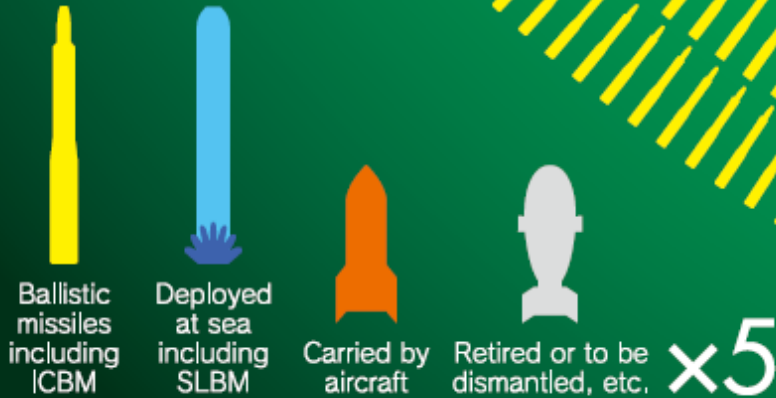


This photograph, taken from a series of kites five weeks after the great earthquake of April 18, 1906, shows the devastation brought on the city of San Francisco by the quake and subsequent fire. (photo courtesy of Harry Myers)



R
The

Ballistic missile
Deployed at sea
Carried by aircraft
Retired or to be
dismantled, etc.



Ballistic missiles including ICBM1,567
 Deployed at sea including SLBM1,228
 Carried by aircraft1,540
 Retired or to be dismantled, etc.3,650

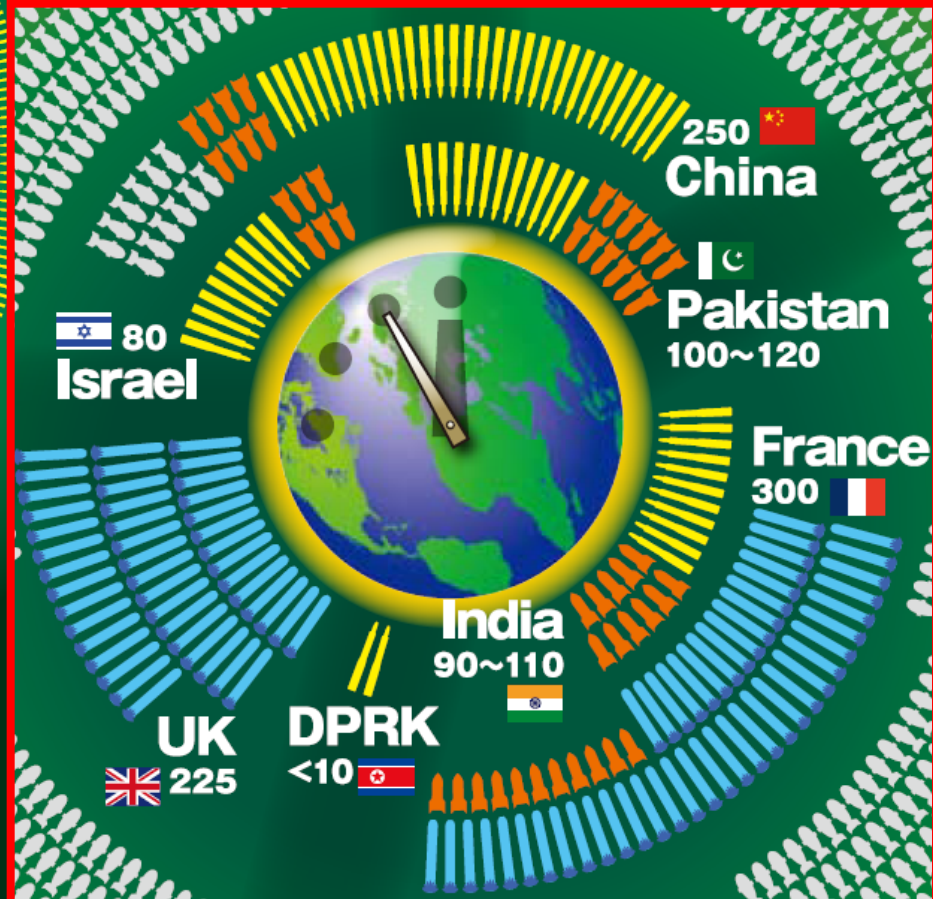
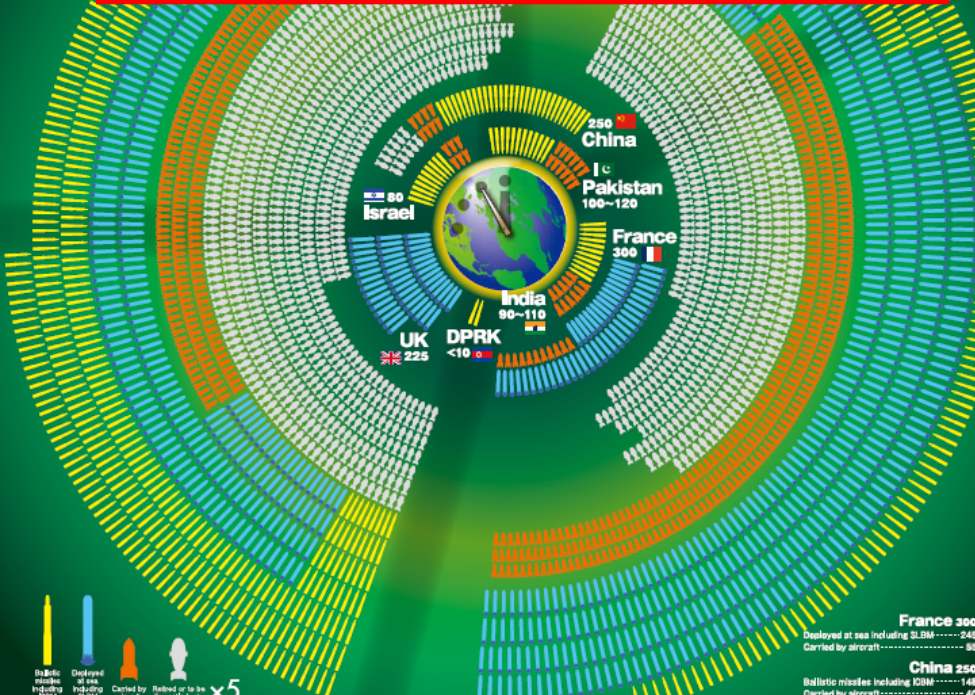
Russia 8,000



US 7,310



Ballistic missiles including ICBM860
 Deployed at sea including SLBM2,304
 Carried by aircraft1,600
 Retired or to be dismantled, etc.2,550



16,400

Decrease from 2013 : -900
 USA : -400
 Russia : -500

The
Doomsday
Clock
(see the center)

The Doomsday Clock is a symbol of the threat of nuclear annihilation. On the clock, midnight is the time of total destruction of humanity, and the minute to midnight illustrates how close we are to such a "doomsday". Currently it is "90 minutes to midnight."

France 300
 Deployed at sea including SLBM245
 Carried by aircraft55

China 250
 Ballistic missiles including ICBM148
 Carried by aircraft50
 Retired or to be dismantled, etc.50

UK 225
 Deployed at sea including SLBM225

Israel 80
 Ballistic missiles including ICBM80
 Carried by aircraft0

Pakistan 100~120
 Ballistic missiles including ICBM60
 Carried by aircraft60~90

India 90~110
 Ballistic missiles including ICBM54
 Carried by aircraft36~66

DPRK <10
 ? Ballistic missiles including ICBM<10



Photo courtesy of National Nuclear Security Administration / Nevada Site Office.





0665



Illustration by Jon Lomborg



What if India and Pakistan had a nuclear war?

Imagine a skirmish in Kashmir escalating, due to poor communication, misunderstanding, panic, and fear.

What would be the consequences of a regional nuclear war using 100 15-kT (Hiroshima-size) weapons?

This would be only 0.03% of the current world arsenal.

Scenario: Weapons dropped on the 50 targets in each country that would produce the maximum smoke.

20,000,000 people would die from direct effects, half of the total fatalities from all of World War II.

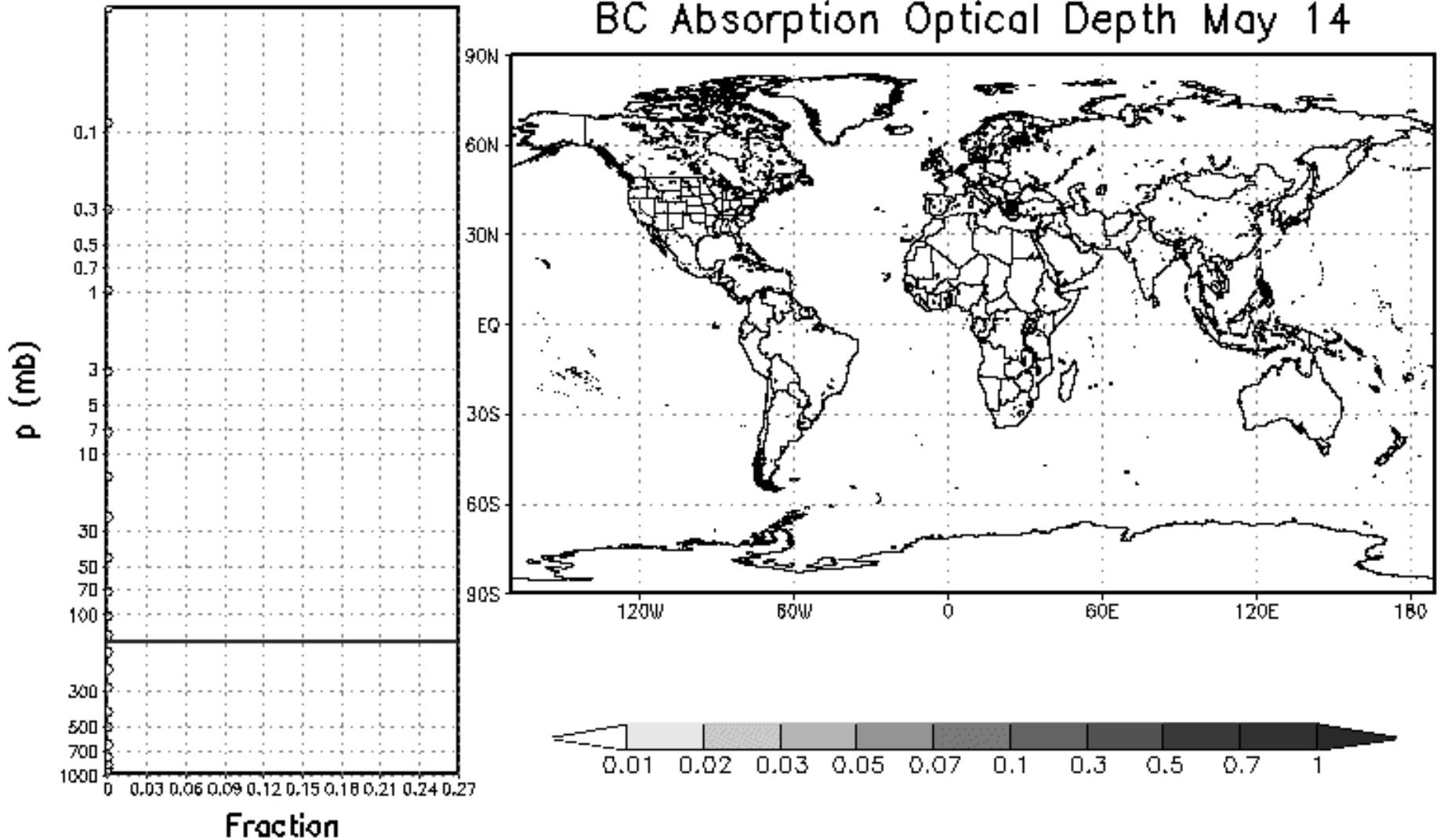
Portions of megacities attacked with nuclear devices or exposed to fallout of long-lived isotopes would likely be abandoned indefinitely.

5 MILLION TONS (TG) OF SMOKE

injected into the upper troposphere, accounting for fuel loading, emission factors and rainout.

BC per model level

BC Absorption Optical Depth May 14

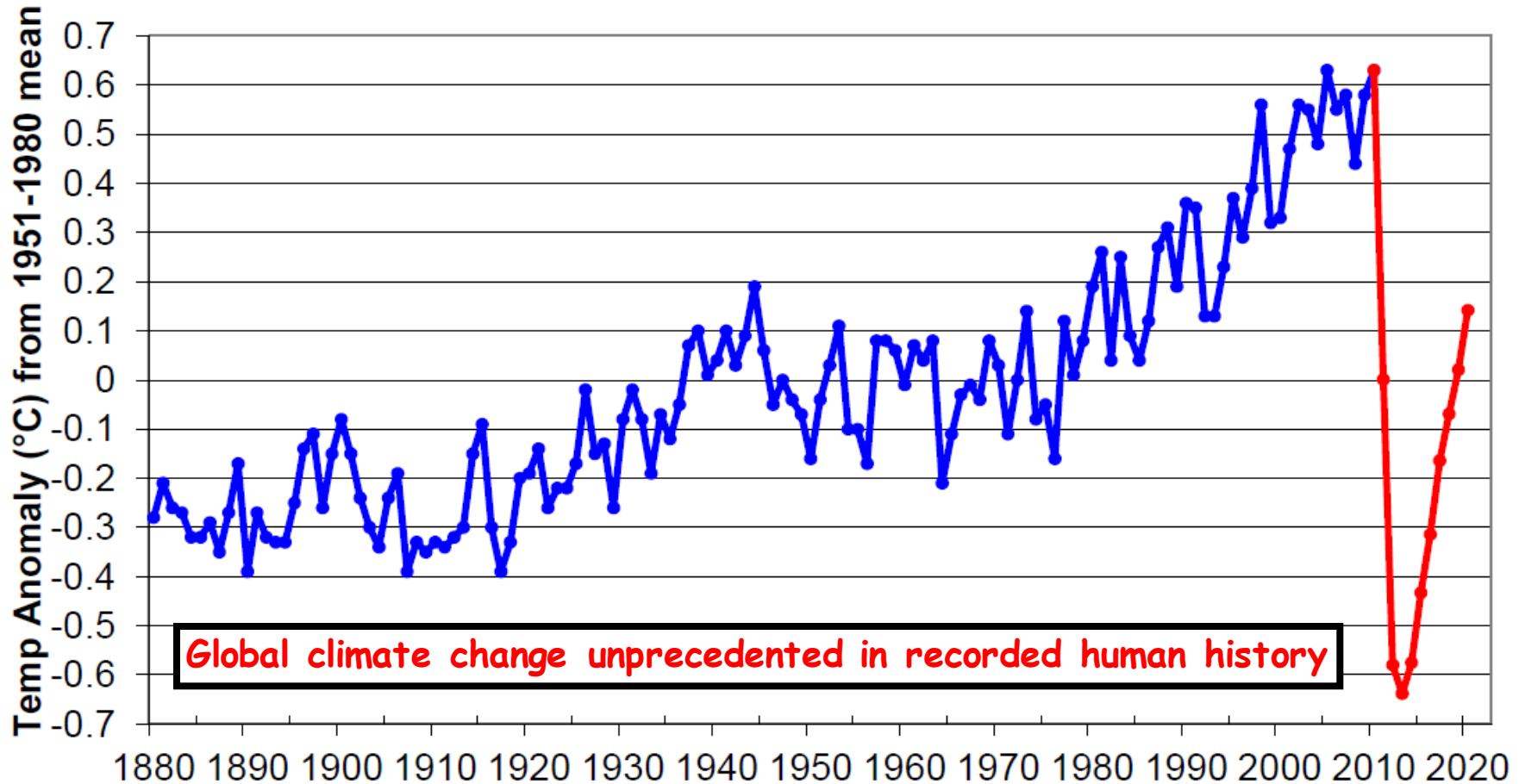


Daily smoke loading from one ensemble member.

Absorption optical depth of 0.1 means that 90% of radiation reaches the surface.

GISS Global Average Temperature Anomaly

+ 5 Tg smoke in 2011



Two other climate models have now simulated the impacts of 5 million tons of smoke injected into the upper atmosphere from fires from nuclear attacks.

Stenke, Andrea, et al., 2013: Climate and chemistry effects of a regional scale nuclear conflict, *Atmos. Chem. Phys.*, **13**, 9713-9729, doi:10.5194/acp-13-9713-2013.

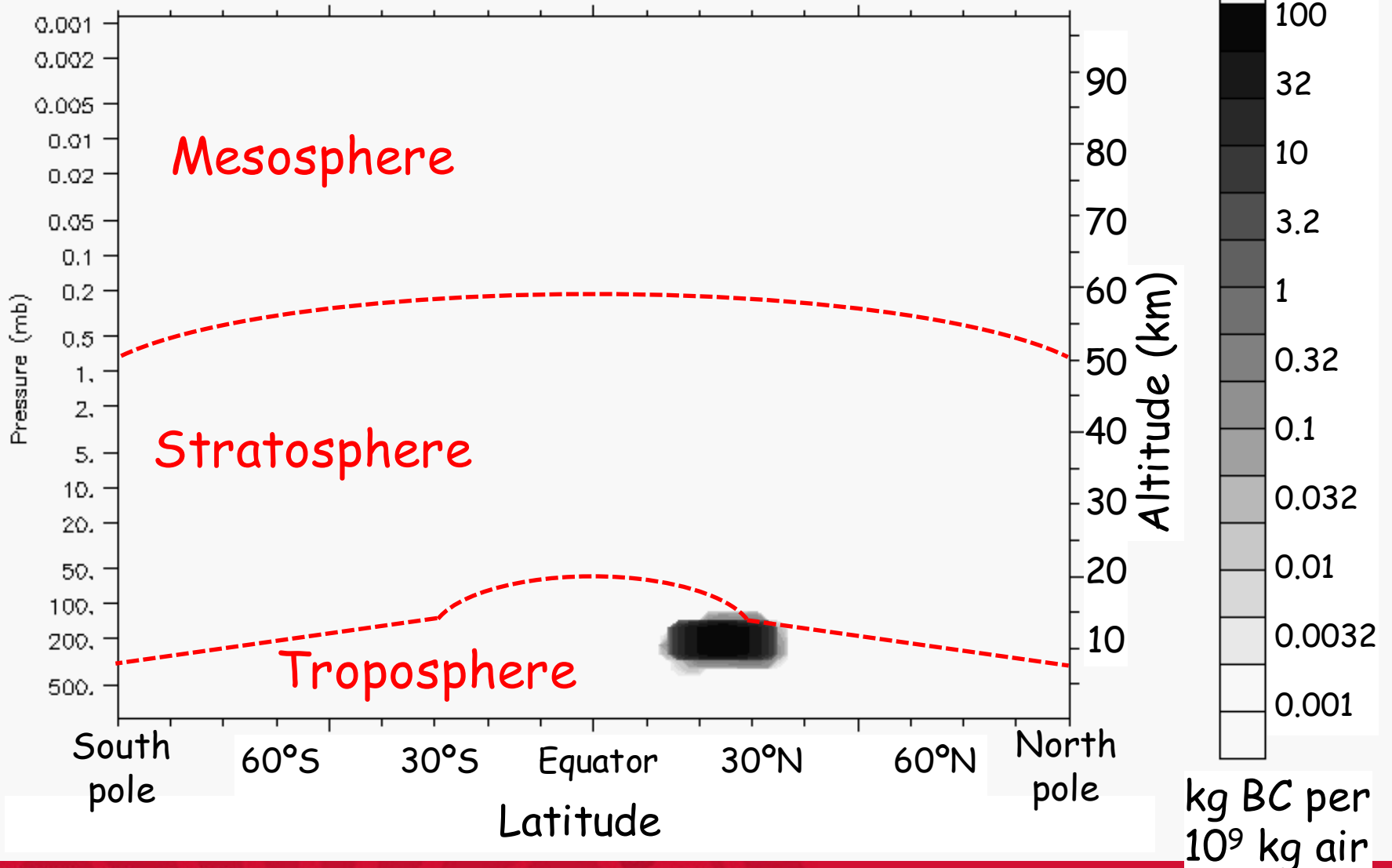
Mills, Michael J., Owen B. Toon, Julia Lee-Taylor, and Alan Robock, 2014: Multi-decadal global cooling and unprecedented ozone loss following a regional nuclear conflict. *Earth's Future*, **2**, 161-176, doi:10.1002/2013EF000205.

All three find global cooling for more than a decade, unprecedented in recorded human history.

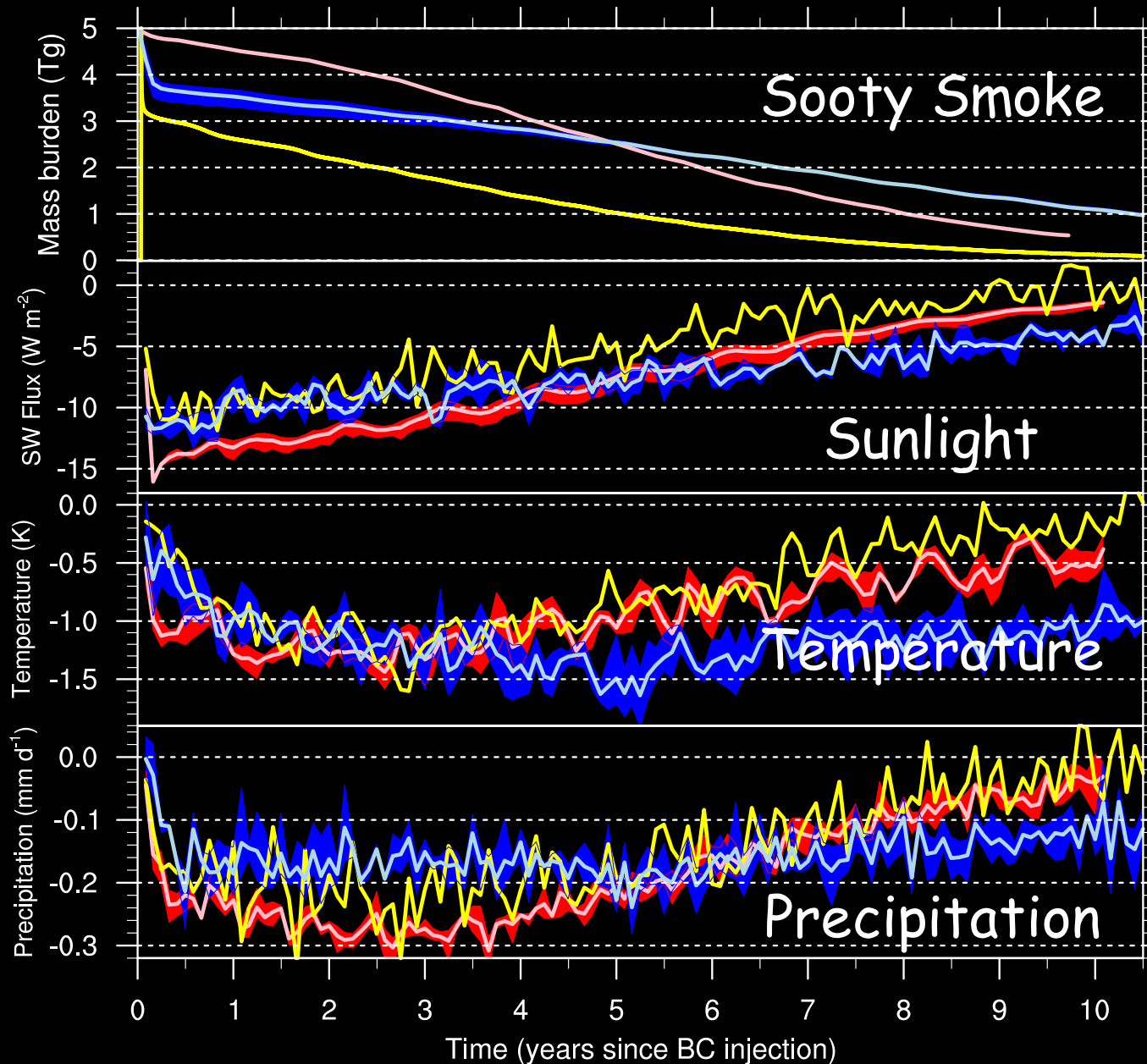
(This is from "only" 100 15-kt bombs, much less than 1% of the global nuclear arsenal.)

Black carbon mass mixing ratio

SOOT01 [kg/kg], 01Jan2013 00:00



Global climate response to regional war

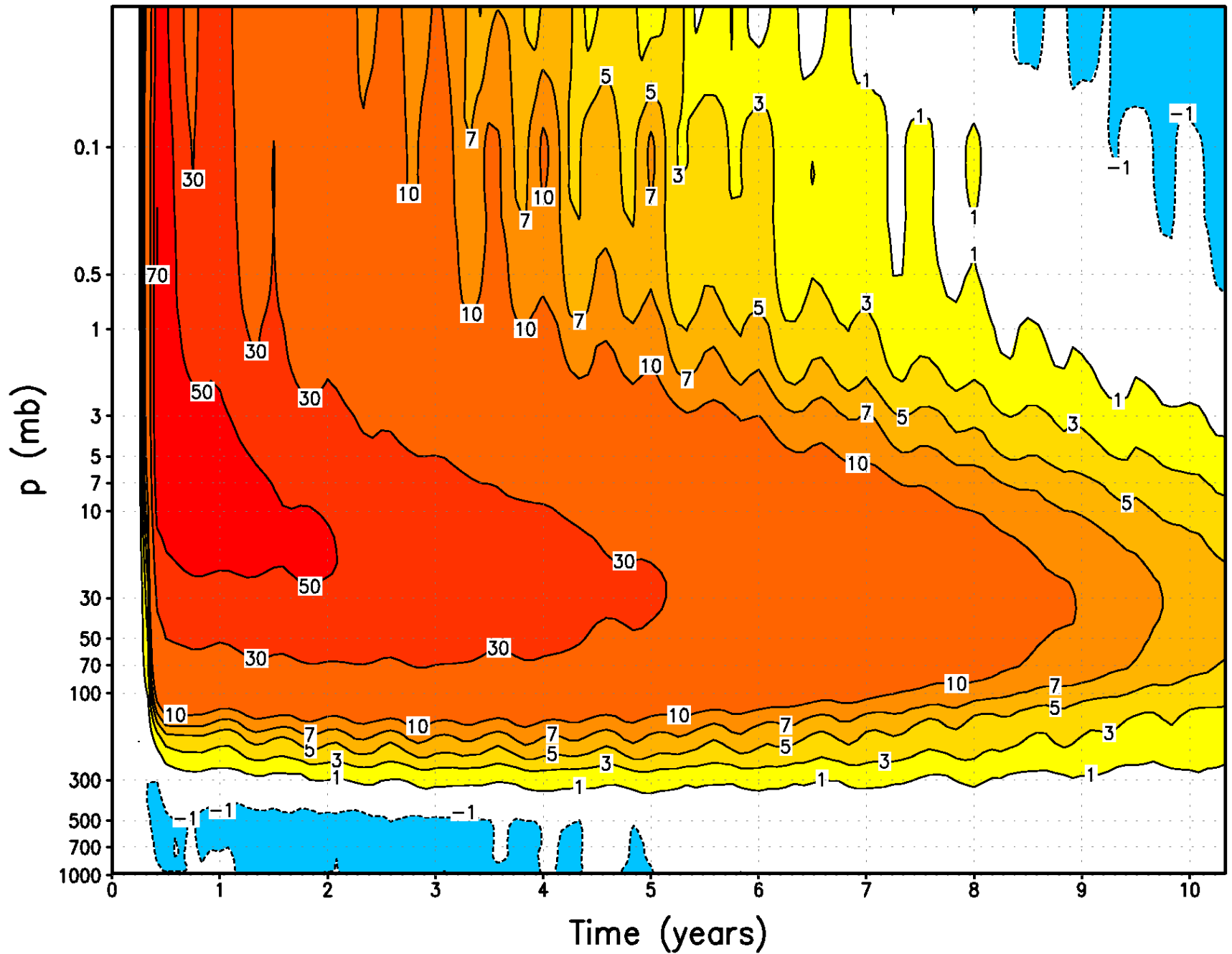


GISS Model E
full ocean
no chemistry
response
Robock et al. (2007)

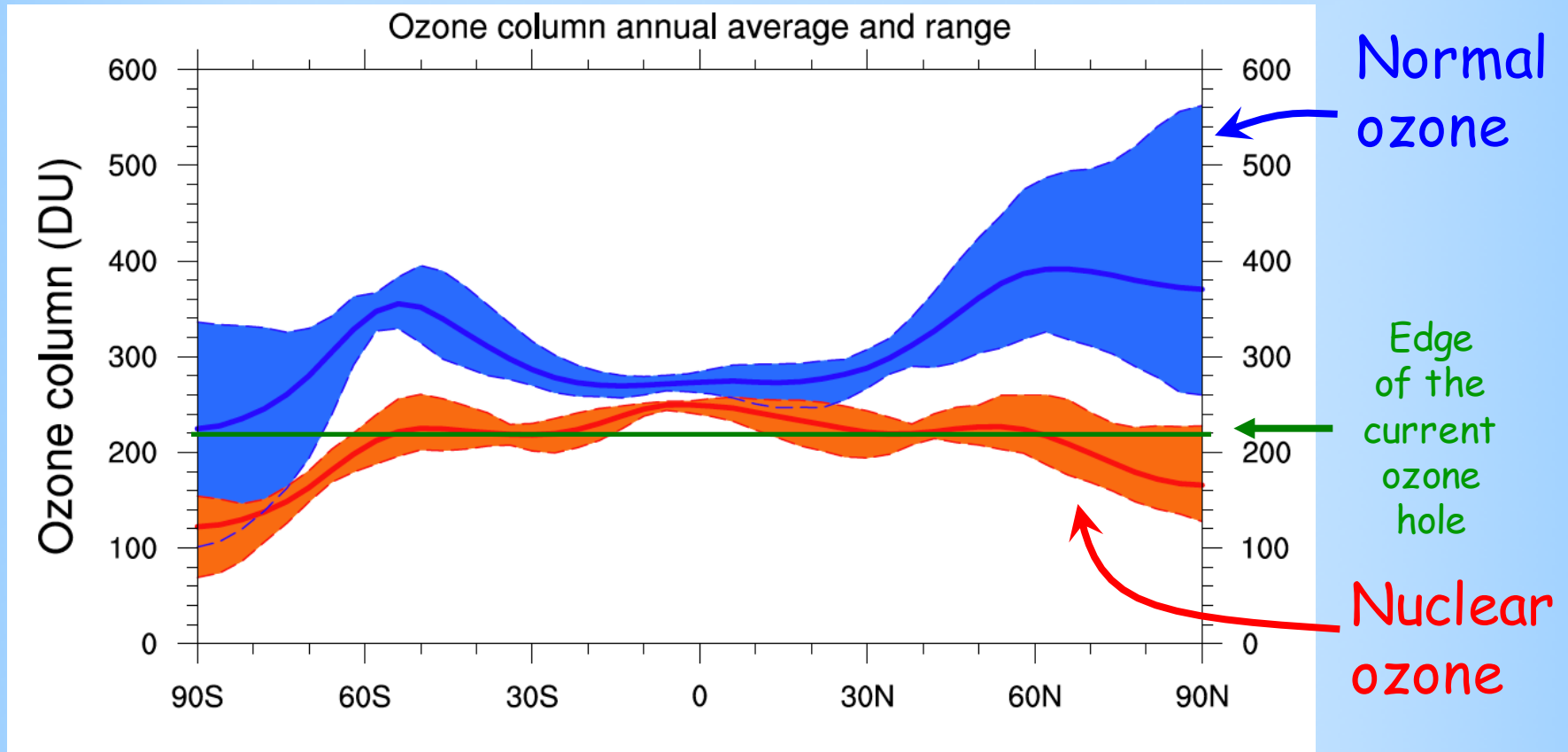
SOCOL
ozone chemistry
shallow ocean
Stenke et al. (2013)

CESM(WACCM)
ozone chemistry
full ocean,
sea ice, land
Mills et al. (2014)

Change in Global Temperature ($^{\circ}\text{C}$) Profile



Ozone depletion 3 years after soot injection



Mills, Michael J., Owen B. Toon, Richard P. Turco, Douglas E. Kinnison, and Rolando R. Garcia, 2008: Massive global ozone loss predicted following regional nuclear conflict, *Proc. Nat. Acad. Sci.*, **105**, 5307-5312.

We calculated how agricultural production would change in the 10 years following a nuclear war between India and Pakistan, using crop models, for:

Maize (corn) and soybeans in the US Midwest

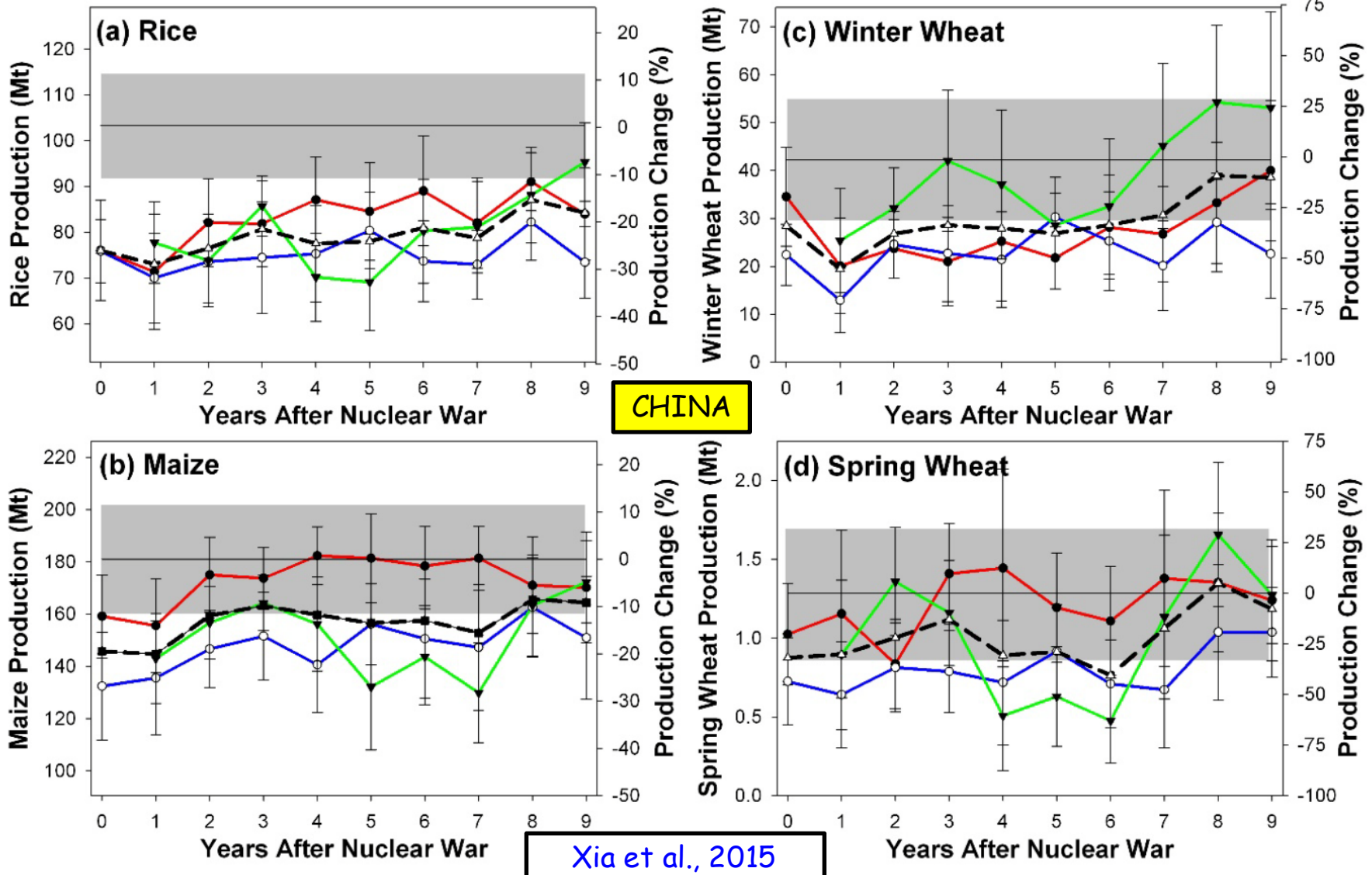
Rice, maize, and wheat in China

Özdoğan, Mutlu, Alan Robock, and Christopher Kucharik, 2013: Impacts of a nuclear war in South Asia on soybean and maize production in the Midwest United States. *Climatic Change*, **116**, 373-387, doi:10.1007/s10584-012-0518-1.

Xia, Lili, and Alan Robock, 2013: Impacts of a nuclear war in South Asia on rice production in mainland China. *Climatic Change*, **116**, 357-372, doi: 10.1007/s10584-012-0475-8.

Xia, Lili, Alan Robock, Michael Mills, Andrea Stenke, and Ira Helfand, 2015: Decadal reduction of Chinese agriculture after a regional nuclear war. *Earth's Future*, **3**, 37-48, doi:10.1002/2014EF000283.

Crop yield changes forced by climate changes of three Climate Models



- GISS ModelE
- WACCM
- ▼ SOCOL
- ▲ Average of three models
- Control run

Error bars are one standard deviation of grain production simulated from climate forcing of three climate models including 30 climate conditions for each year. The gray area shows one standard deviation from the 30-year control run, illustrating the effect of interannual weather variations

How agricultural production would change in the 10 years following a nuclear war between India and Pakistan

(not considering damage from excess UV yet)

Summary:

	<u>First 5 years</u>	<u>Second 5 years</u>
US maize	-20%	-10%
US soybeans	-15%	-10%
China maize	-15%	-10%
China middle season rice	-25%	-20%
China spring wheat	-25%	-20%
China winter wheat	-40%	-25%



Chronic Malnutrition Today

Minimum daily requirement: 1,800-2,200 calories

900 million people below this level of daily intake



**2 billion dead
from starvation
alone?**

NUCLEAR FAMINE: A BILLION PEOPLE AT RISK

Global Impacts of Limited Nuclear War on Agriculture,
Food Supplies, and Human Nutrition

*2012 report by Ira Helfand, MD
International Physicians for the Prevention of Nuclear War
Physicians for Social Responsibility*

Former Soviet President Mikhail Gorbachev observed on reviewing the new “Nuclear Famine” study: “I am convinced that nuclear weapons must be abolished. Their use in a military conflict is unthinkable; using them to achieve political objectives is immoral.

“Over 25 years ago, President Ronald Reagan and I ended our summit meeting in Geneva with a joint statement that ‘Nuclear war cannot be won and must never be fought,’ and this new study underscores in stunning and disturbing detail why this is the case.”

(CNN.com, May 11, 2012)

One U.S. Trident submarine has 96 nuclear weapons, each 100 or 475 kt, making each Trident more powerful than 1000 Hiroshimas.



The U.S. has 14 Tridents, and that is less than half the U.S. nuclear arsenal.

What would be the consequences of a full-scale nuclear war between the US and Russia?

We use the NASA GISS ModelE atmosphere-ocean general circulation model.

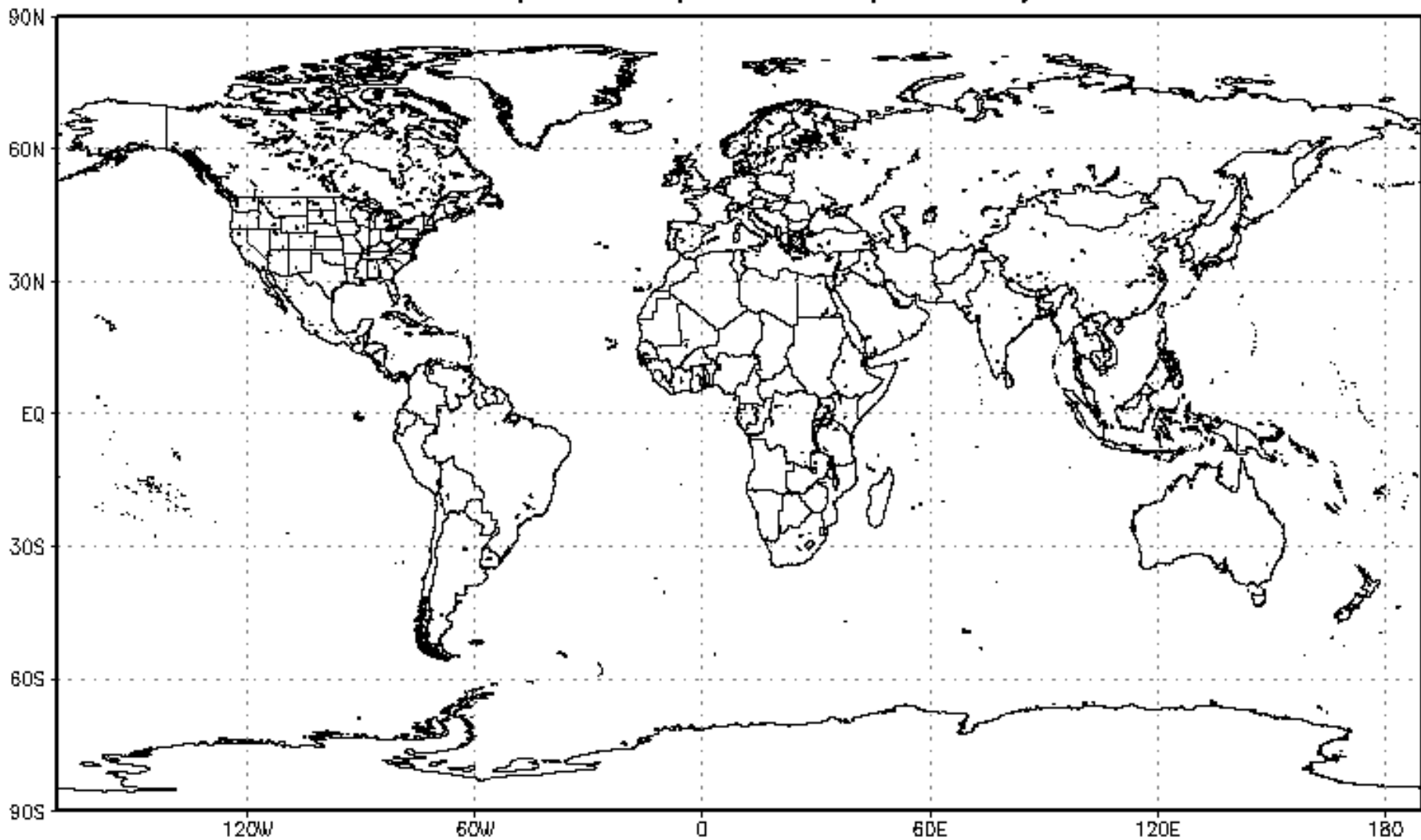
- 50 Tg or 150 Tg of smoke into the 300-150 mb layer (upper troposphere) over the US and Russia on May 15
- 30-yr control run, two 10-yr runs (50 Tg or 150 Tg)

What could produce 150 Tg of smoke?

- standard nuclear winter scenario of 30 years ago
- entire current arsenal if targeted the same way
- only 4000 weapons (2017 global arsenals of New START treaty)

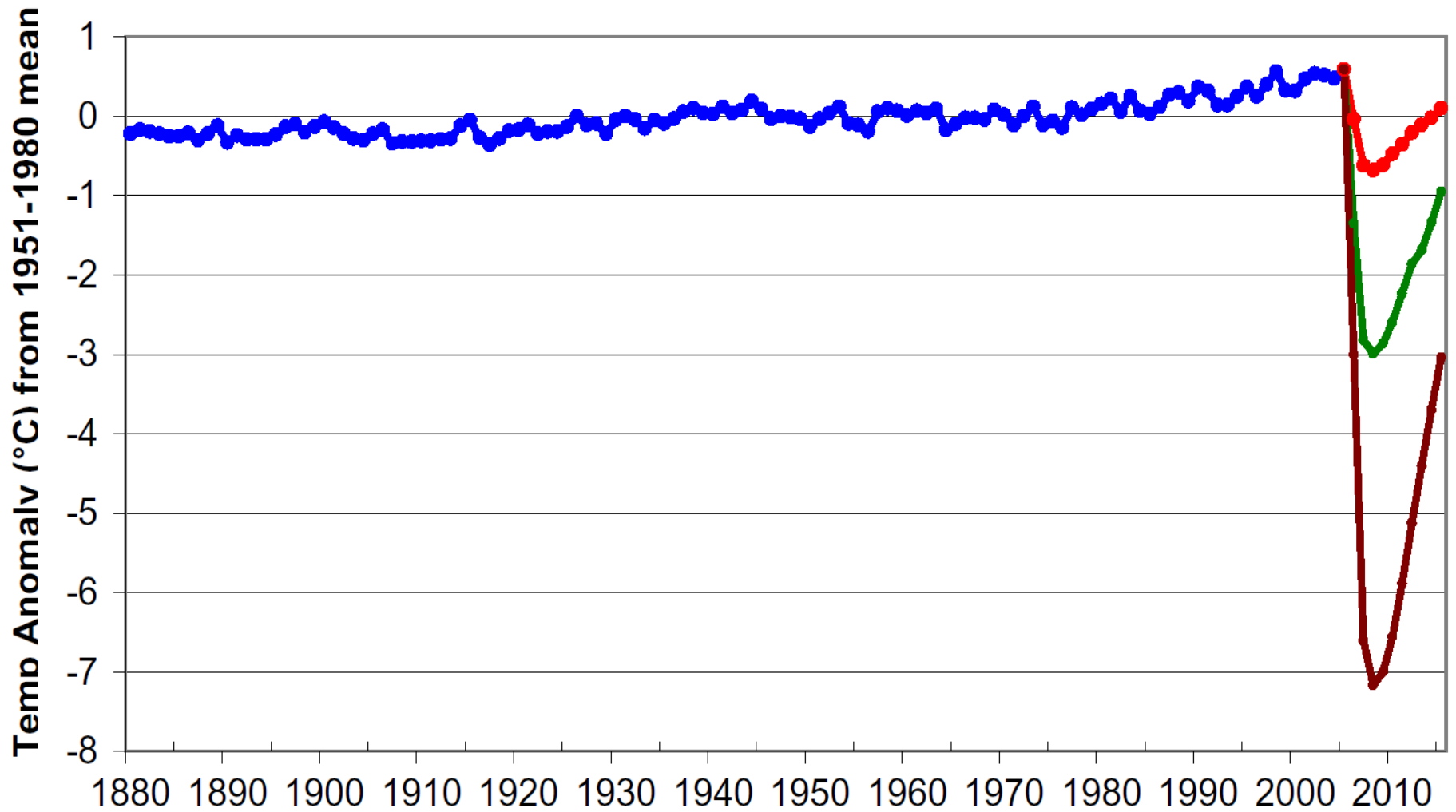
Robock et al., 2007b

BC Absorption Optical Depth May 14th



GISS Global Average Temperature Anomaly

+ 5 Tg, 50 Tg, 150 Tg smoke in 2006



Temperature Change (°C) w.r.t. 1990

Reference: SRES A1B-AIM (Illustrative Scenario)

Policy: Nuclear War in 2020

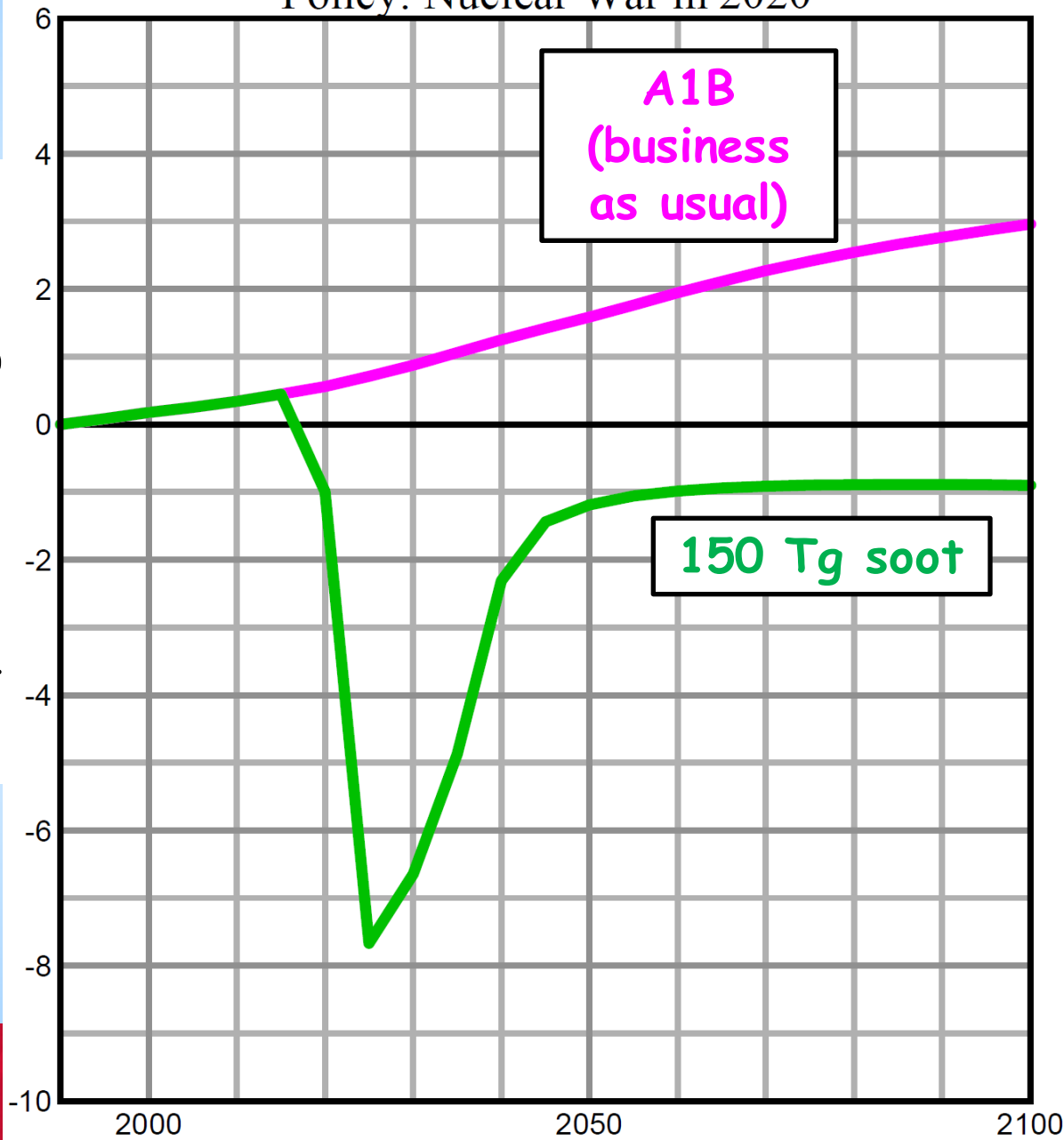
150 Tg soot into the upper troposphere

Anthropogenic emissions stop

MAGICC energy-balance model simulation with climate sensitivity of 3 K for doubling CO_2

Would solve global warming problem!

Temperature change (K)



What's New?

A nuclear war between any nuclear states, using much less than 1% of the current nuclear arsenal, would produce climate change unprecedented in human history.

Such a "small" nuclear war could reduce food production by 20% to 40% for a decade, with massive increases in ultraviolet radiation.

Nuclear winter theory was correct.

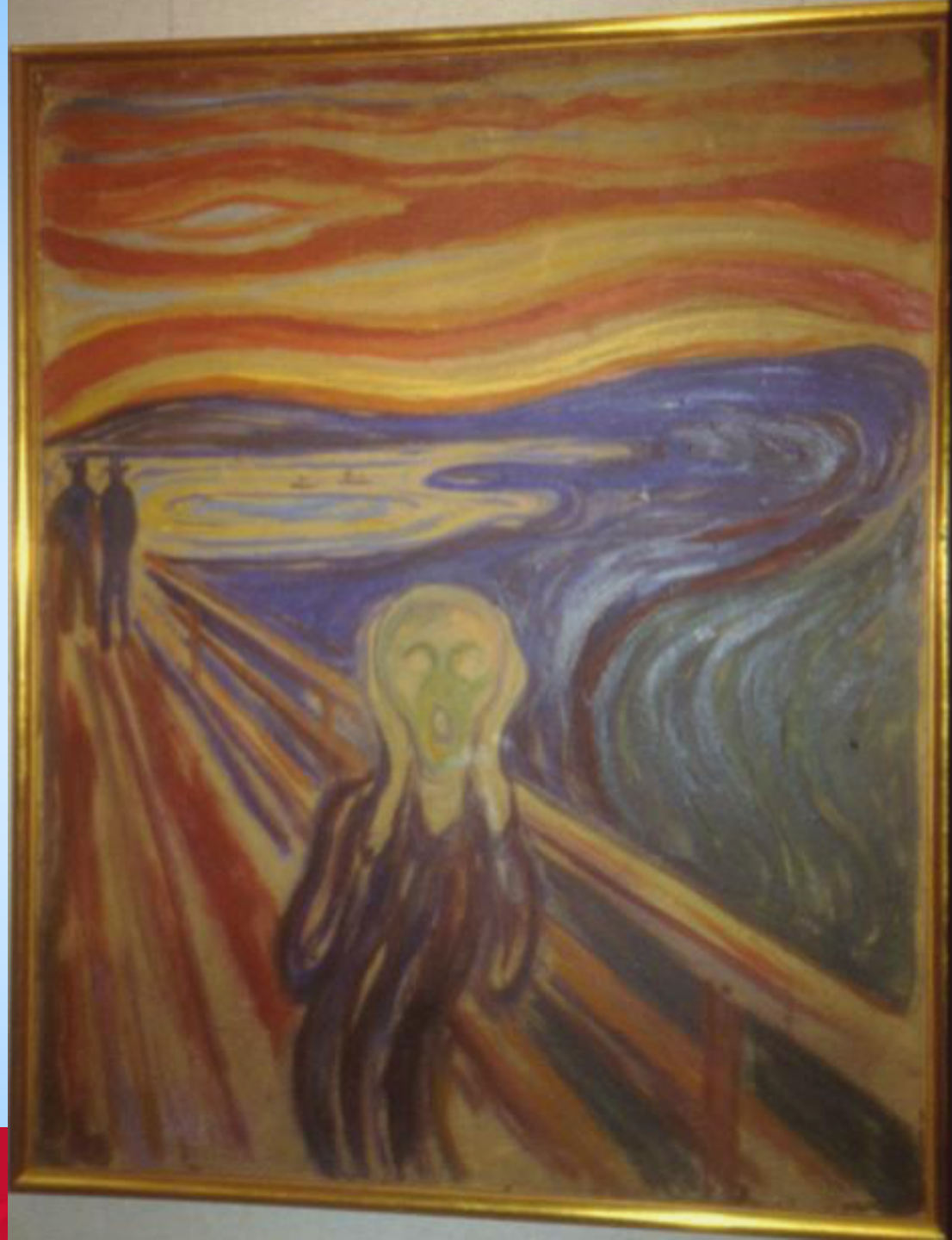
The current arsenal can still produce nuclear winter.

The effects of regional or global nuclear war would last for more than a decade.

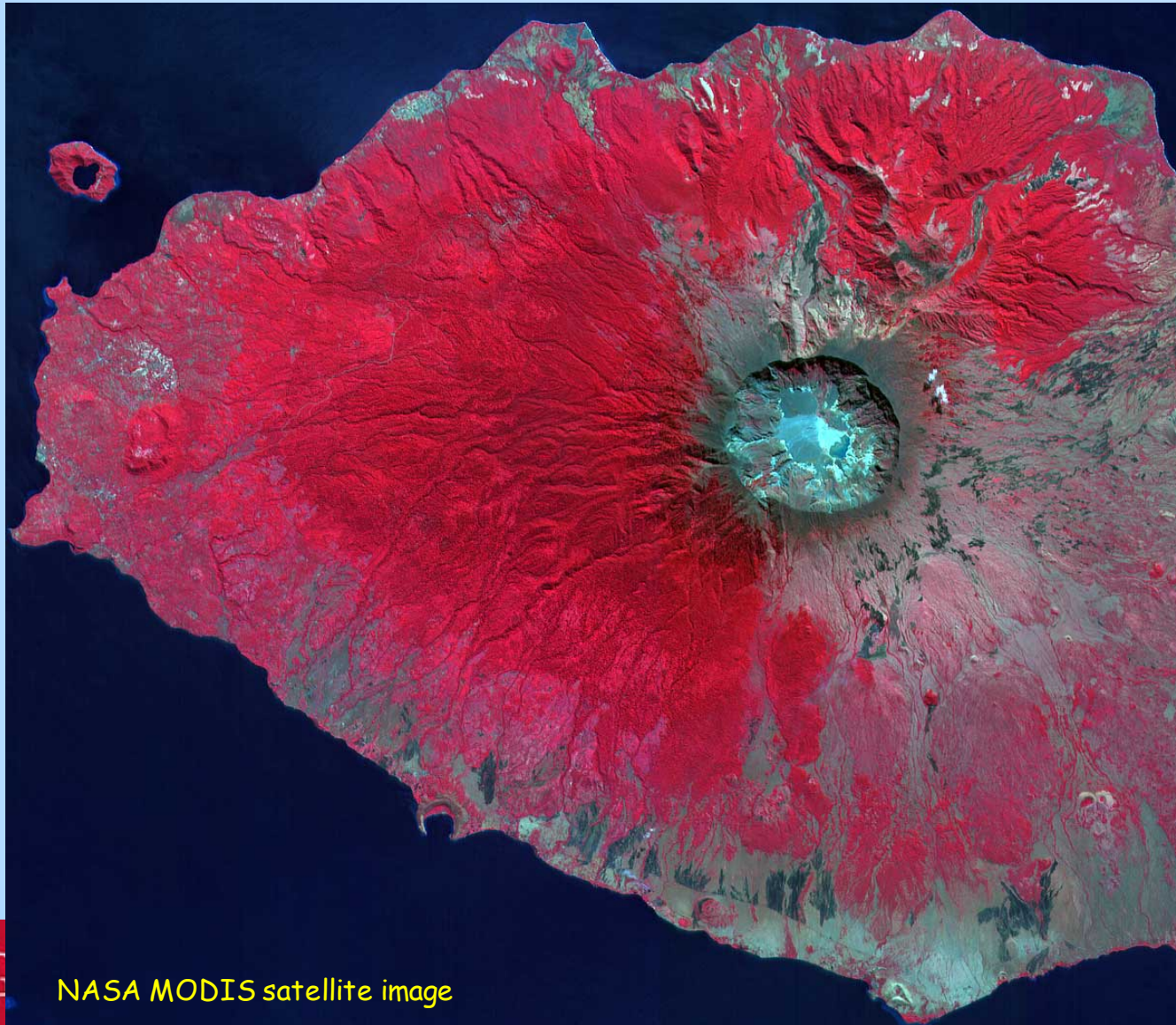
“The Scream”

Edvard Munch

Painted in 1893
based on Munch’s
memory of the
brilliant sunsets
following the
1883 Krakatau
eruption.



Tambora in 1815, together with an eruption from an unknown volcano in 1809, produced the “Year Without a Summer” (1816)





LORD BYRON
POÈTE ANGLAIS
AUTEUR DU
PRISONER of CHILLON
HABITA LA
VILLA DIODATI
EN 1816
YCOMPOSA LE 3^{me} CHANT
DE
CHILDE HAROLD



Tambora, 1815, produced the “Year Without a Summer” (1816)

“Darkness” by Byron



I had a dream, which was not all a dream.
The bright sun was extinguish'd, and the stars
Did wander darkling in the eternal space,
Rayless, and pathless, and the icy earth
Swung blind and blackening in the moonless air;
Morn came and went—and came, and brought no day,
And men forgot their passions in the dread
Of this their desolation; and all hearts
Were chill'd into a selfish prayer for light:
And they did live by watchfires—and the thrones,
The palaces of crowned kings—the huts,
The habitations of all things which dwell,
Were burnt for beacons; cities were consumed,
And men were gather'd round their blazing homes
To look once more into each other's face; . . .

Bulletin of the Atomic Scientists

IT IS 5 MINUTES TO MIDNIGHT



Feature

Self-assured destruction: The climate impacts of nuclear war

Alan Robock and Owen Brian Toon

Bulletin of the Atomic Scientists

68(5) 66–74

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<http://thebulletin.sagepub.com>



<http://climate.envsci.rutgers.edu/pdf/RobockToonSAD.pdf>



President Barack Obama and President Dmitry Medvedev of Russia sign the New START Treaty during a ceremony at Prague Castle in Prague, Czech Republic, April 8, 2010.

Policy Implications of the Use of Nuclear Weapons

Only nuclear disarmament will prevent the possibility of a nuclear environmental catastrophe.

Continuing American and Russian reductions set an example for the world, maintain the nuclear deterrence of each, and dramatically lower the chances of nuclear winter, **but are not enough.**

Policy Implications

1. **Immediate American and Russian reductions** to the same arsenal sizes of the other nuclear nations, about 200 weapons each, would maintain the nuclear deterrence of each and **prevent nuclear winter.**
2. **Nuclear abolition** will **prevent nuclear famine.**



"For myself, I would far rather have a world in which the climatic catastrophe cannot happen, independent of the vicissitudes of leaders, institution, and machines. This seems to me elementary planetary hygiene, as well as elementary patriotism."

-Carl Sagan

"Elementary planetary hygiene" demands that we eliminate nuclear weapons faster.

“How does
it feel?”

Bob Dylan (1965), *Like a
Rolling Stone*



I'm sorry. This has really been a bummer, and it was not nice of me to present you with such a depressing story.

So what do you do with this information?

The most natural reaction is to try to forget it. As Mark Twain said,

"Denial ain't just a river in Egypt."

WEAPONS ALREADY BANNED

There are already international conventions prohibiting biological weapons, chemical weapons, land mines and cluster munitions, but no comparable treaty – as yet – for nuclear weapons. The international community must address this legal anomaly. As with the negotiating

processes that resulted in treaties banning land mines and cluster munitions, likeminded governments should work in close partnership with civil society to bring about a nuclear weapons ban regardless of resistance from states possessing the weapons.



X BIOLOGICAL WEAPONS

Banned under the Biological Weapons Convention

1972



X CHEMICAL WEAPONS

Banned under the Chemical Weapons Convention

1993



X LAND MINES

Banned under the Anti-Personnel Mine Ban Treaty

1997



X CLUSTER MUNITIONS

Banned under the Convention on Cluster Munitions

2008



NUCLEAR WEAPONS

NOT YET BANNED BY TREATY

BAN NUCLEAR WEAPONS NOW

<http://www.icanw.org>





R-12 ROCKET (SS-4)

Middle range ballistic rocket belonging to the Strategic Rocket Troops

Length: 22.1 m

Diameter: 1.65 m

Weight: 27 200 Kg

Range: 700 to 2100 Km

Power of nuclear load: 1 megaton (77 times more powerful than the bomb which devastated Hiroshima).

Three regiments arrived in Cuba with a total of 36 operational rockets with 36 nuclear heads. These were positioned at three ports: Bahia Honda, Mariel and Casilda at the Pinar del Rio province.

The exhibit is a replica donated by the Soviet Government during the early years of the Revolution.

Scenes from the
1992 Gulf War



*By a debate
Sept. 14 de 2010*



Fidel Castro Ruz

Reflexiones
Sept. 23, 2010



“While the United States and Russia each committed to reducing their operative nuclear arsenals down to some 2,000 weapons in April 2010 in Prague, the only way to prevent a global climate catastrophe from taking place would be by eliminating nuclear weapons.”



OEWG 2016: The door has been re-opened

The UN Open Ended Working Group on Taking Forward Multilateral Nuclear Disarmament Negotiations has been re-established by the 70th UN General Assembly. Encourage your country to participate and make the 2016 OEWG deliberations a success.

'A very little key will open a very heavy door'
Charles Dickens

In October 2015, states decided to hold a second OEWG to address concrete effective legal measures, legal provisions, and norms that will need to be concluded to attain and maintain a world without nuclear weapons. It will operate as a subsidiary body of the General Assembly.

First session: 22-26 February

Second session: 2-13 May (no session on 5 and 6 May)

Third session: 22 August (TBC)

The Opinion Pages | OP-ED CONTRIBUTORS

Let's End the Peril of a Nuclear Winter

By ALAN ROBOCK and OWEN BRIAN TOON FEB. 11, 2016



Five Myths About Nuclear Weapons

Ward Wilson, *New York Times*, January 13, 2013

1. Nuclear weapons altered the course of World War II. (66 Japanese cities were destroyed by conventional weapons. Two more did not make a difference.)
2. Decisive destruction. (Mass destruction doesn't win wars; killing soldiers does.)
3. Nuclear deterrence. (Did not stop Falklands War, Yom Kippur War, or Soviets after World War II. Who won the wars in Afghanistan and Vietnam?)
4. Nuclear weapons have "kept the peace." (Absence of nuclear war since 1945 does not prove this.)
5. Irreversibility. (Technology cannot be uninvented, but it fades when no longer useful.)



**“Unless someone like you
cares a whole awful lot,
nothing is going to get
better. It's not.”**

Dr. Seuss, The Lorax (1971)



For more about this work, go to
<http://climate.envsci.rutgers.edu/nuclear/>