Aerosol effects in radiative transfer as seen through the paintings of the great masters

Christos Zerefos Academy of Athens



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The volcano Tambora, in 1815, created the «Year Without Summer» (1816)



"Darkness" by Lord Byron (1788-1824)

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; . . .

Volcanic aerosols improve our knowledge of the climate of the past





Frozen Thames 1677



The Temple staires with People grang upon the lee to Temple street A. The Dake of Urke's Coffee house B. The True Beeth C. The Beeth with a Phanix on it and Insured as long as the Foundation stand D. The Reast Beeth E. The half may house 'F. The Beare gorden Shire Booth G. The Musick Beeth H.The Printing Beeth I.The Lettery Booth K.The Hone Tavern Booth L.The Printing Beeth Crowle of People looking over the wall Mathe Beat drawne with a Hors Nithe Printing Beeth E. Beat drawne with a Hors Nithe Draw Beat Othe Beat drawne with a Hors Nithe Draw Beat Othe Beat

Annual mean temperatures at ten European sites with long term records



The chromatic understanding of the artist changes after the eruption of Tambora in 1815, and returns to normal levels after a few years

1817: 2 years after Tambora

Caspar David Friedrich, "Neubrandenburg", 1817 Greifswald, Pommersches Landesmuseum

Caspar David Friedrich, "Schiffe im Hafen von Greifswald",1818 Berlin, Alte Nationalgalerie

1818: 3 years after Tambora



Friedrich Caspar David (1774-1840)

Sunset after Tambora



Sunset without volcano



"Woman in front of the Setting Sun", 1818, Museum Folkwang, Essen, Γερμανία

"Evening", 1824, Kunsthalle, Manheim, Γερμανία



Caspar David Friedrich, Griefswald in the Moonlight, 1817. Corresponding R/G ratios were averaged inside each box.



Karl Friedrich Schinkel, The Banks of the Spree near Stralau, 1817. Corresponding R/G ratios were averaged inside each box.



Caspar David Friedrich, Woman in front of the Setting Sun, 1818. Corresponding R/G ratios were averaged inside each box.



Joseph Mallord William Turner, Red sky and crescent moon, c. 1818. Corresponding R/G ratios were averaged inside the box.

J.M.W. Turner (1775-1851)

Sunset after Babuyan



"Sunset", 1833, Tate Gallery

Sunset without volcano



«Chichester Canal», 1828, Tate Gallery

R/G ratios in the painting "Sunset"



R/G ratio and respective AOD (Unknown volcano ~1809)



Plate 19 John Constable, Dedham Vale, 1810. Private collection



Plate 20 John Constable, The River Stour at Sunset, 1809. Private collection

Thornes, J.E., "John Constable's Skies: A Fusion of Art and Science", University Press, 1999 1810 R/G ratio = 1.021 AOD ≈ 0.22

1809 R/G ratio = 1.137 AOD ≈ 0.30 Linear correlation between annual mean aerosol optical depth at 550 nm, estimated from sunset paintings following volcanic eruptions, and mean annual values of DVI. The errors in the AOD are less than 0.05 for values around 0.1 and can be up to 0.18 for AOD values greater than 0.5.



SPE Analysis with key year the volcanic eraption with VEI ≥ 5 for AOD and Temperature



Climatic stations: Basel, Berlin, Geneva, Greenwich, Moscow, Paris, Prague, Corfu, St Petersburg, Stokholm

The active volcano Laki in Iceland











Aerosol optical depth from paintings and other proxy indices during the past 500 years from different proxies (Zerefos et. al., 2014)

The experiment of Hydra island (19 & 20 June 2010)



Upper: Digitally compressed paintings by P. Tetsis at the Hydra experiment under higher (left panel) and lower (right panel) AOD conditions. Bottom: Digital camera photos of the landscape.

Passage of a Saharan dust event



MFR-7 AOD retrievals at 500 nm on 19 and 20 June 2010 at Hydra campaign site. Microtops II AOD retrievals at 1020 nm are superimposed

The profile of Saharan dust



Aerosol measurements during the two days of the experiment



Percent difference in R/G ratios between the measured at Hydra Sahara dust mineral aerosol profile and a typical modelled volcanic aerosol profile. In both cases AOD (500 nm) was set to 0.25.



(DVI) Independent index of volcanic aerosols. *(AOD)* Absorption of solar radiation in the atmosphere from measurements in paintings.



guardian.co.uk

How old masters are helping study of global warming

Paintings of striking sunsets show effect of huge volcanic eruptions on climate

- David Adam, environment correspondent
- The Ouardian
- Monday Celaber 1 2007

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David Adam

November 09, 2007

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aspar David Friedrich, Edger Degas oder William Turner malten Sonnemantergänge in überwähtigenden Far-

ben. Jetzt bekommen ihre Gemälde REUTERS 🏟

Classic paintings had a helping hand from

volcano Thu Oct 4, 2007 12:10pm EDT

By Karolos Grohmann

use of other to which such as AMM. Turner, responsed for his expansion desirther of AdA, formed, Rubers, Degan and Databarray), and the bit to universe explores a staggering. Used source of Assessment Process Anistan AdV.

des said its 1991 eruption of inderessits Tambers release sampt solves all its way to Dampe indiag the configurations not and burning \$196 into a "year solbout agreement"

Turner depicted that is his design and surgedy," he had Readers on Thursday,

Other relation employs that influenced painted surrowly is the 1887 employe of the Kalashia volume in Information

Zeerics said he used a dust will leder, created by Dillah 2011 century climatologist Habert Lamb to shalo catanic orugitane and best relation to be climate.

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sis team abudied hundreds of paintings up until atmospheric data atasted being collected is the 2011 contrary and said the adult warm and adults in participants of a real ratios as here any fears in ratios

hat may be a fair assumption for impressionists but even with Expressionists this is the case. His ing "he set. "It is the first time we are build to sale all based on the environment

Next so is a study of 20th century which is see how all publics has influenced flash use of other

To cape more selled who paints backscapes to send me his paintings in digital form so we can also been." Descine well

RESEARCH HIGHLIGHTS

Volcanic paintings

Atmos. Chem. Phys. 7, 4027-4042 (2007) The ash from large volcanic eruptions can cool Earth's climate and cause vivid red sunsets. But the historical effects of volcanic activity on climate are difficult to quantify owing to a lack of direct atmospheric observation.

Christos Zerefos at the Academy of Athens in Greece this colleasure have come up with a novel way to c particle content in middle latitudes isphere during the period 1500sunsets captured in paintings by Wissenschaft · Technik Mallord William Turner, Edgar Degas ictured is one of their subjects. The

by Caspar David Friedrich.) iculated red/green colour ratios from dreds of paintings. They found that after major volcanic eruptions such in 1680 and 1883. The team then used to reconstruct how much light was nic ash in the air. The resulting time with and could complement existing tions of atmospheric composition.

Associated Press NATIONAL GEOGRAPHIC THE 😹 🎰 🕮 HINDU

Art as Window to Climate Change

The virial search painted by J.M.W. Turster are revered the thair new of order and light and the thair Improvidentials. Dut occide they also help global wavening opports track climate charge? A group of wiserfark has shaded the oxions in more than 500 paintings of sumsts, including many of Turwaterselens and eds, in hopes of gaining insights into the conting effects caused by encore volcanic erroritors By better understanding part charges in climate, they hope to improve computer models for fature climate or

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Klima auf der Leinwand

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Tenigren, 03.10.07

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Ζωγραφίζοντας το κλίμα

Tou GEAH KAÏTATZH, 05-10-2007

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msnbc.com

Atmospheric effects of volcanic eruptions as seen by famous artists and depicted in their paintings

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29-11-2007 Ζεγγροφική και κλιμοπικές αλλαγές

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Süddeutsche Zeitung Aus alfen Gemälden kann man einiges lemen. Dass sie auch die

Kilmageschichle abbilden, let neu: Edvar Belapiel waren getreue Chronisten histor THE 🛠 INDEPENDENT Von Axel Bolanowski, 12-10-2007

were a state a biology and contained Art & science: Turner's message from tower on Taxistet. Even occurren tione the skies

with his sector's second to coloris matters

By Geoffrey Lean in Jahr 1863 in Oslo muss sich die Szene abgesg Sunnday, 7 October 2007

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ACCORDEND AND ADDRESS ADDR

Martin Porter Statistics, South

ether Zaun, denn ich war toomate. Oper dem blaus Parter - a precises work of art, interactionly valuable for its own value.

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were relited in the flow prace after regio employs, and controled what was already also afters.

a new huping to study 40 works in the "late, painted in the last century, to see what the on the or many or provide at the long - a tabler had as the effects of reported by or months are been straightforward has from if using one

Old masters, new climate lessons? ecto aid tils Contor at ed that which f nation,* he Palarings of at Malog security deve the effects of large tableads resigned as a Mande. New, Sociel Adam regards, minution are maripeling attemption on Malog Security and the maripeling attemption on Malog Security and the markets gold transmission. dans, who is regarded come and a The Regist having a plane to a lower with the most way and is to exclusion that "to done that such a ways the file". Not a done not regard to being afficiency of the plane blane to import that products of the composition of second basis. conduct finite tid day as a p The entended are maintained for exciting margin particular Terms and denses of other article in terms of the ending effects of larger relation express. By marking entered for element marked particular in the particular particular markets where and the standard particular terms. University of explore and a second detected a particular to the second detected of the second second detected and the second detected and th to looma, 0 ting on their Charles Control to Barrowski barbar and "Third to belong a final and of \$1 and barrows of process in particle and the same field to be a state of the same of the same barrowski and the same of the same barbar and the same of the same wing an arrest ates, the batts The results will find into the plottilk study of a planet source soft of all the decision, which is proved by at public the bid study of a planet space before the base and the e bady or point variance, and the discuss charge could as some of public the bady of reduced. projated 54 of

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The Washington Times -

Authrock des Krobetau 1883

Klima-Archiv in der Galerie

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Kate Schuman, Associated Press, Nov. 29, 2007

brüchen wie etwn der Explosion des indonesischen Kenkatau 1885, der Asche bis zu So Kilometer hoch in die Atmo-

sphäre schleuderte. Die Erkenntaisse sollen nun in aktuelle Klimamodelle einfließen. "Wir können den Klima-

Christian Zeordian, who lad the managesh at the Hational Observatory of Adhams, said he believed it was the fit

Thank you for your attention!