



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

Christos Zerefos
Academy of Athens



«...ΚΑΙ ΤΟ ΠΕΡΙ ΤΟΝ ΗΛΙΟΝ ΑΜΑΥΡΩΜΑ ΤΗΣ ΑΥΓΗΣ. ΟΛΟΝ ΓΑΡ ΕΚΕΙΝΟΝ ΤΟΝ ΕΝΙΑΥΤΟΝ (44 π.Χ.) ΩΧΡΟΣ ΜΕΝ Ο ΚΥΚΛΟΣ (ΤΟΥ ΗΛΙΟΥ) ΚΑΙ ΜΑΡΜΑΡΥΓΑΣ ΟΥΚ ΕΧΩΝ ΑΝΕΤΕΛΛΕΝ, ΑΔΡΑΝΕΣ ΔΕ ΚΑΙ ΛΕΠΤΟΝ ΑΠ' ΑΥΤΟΥ ΚΑΤΗΙ ΤΟ ΘΕΡΜΟΝ, ΩΣΤΕ ΤΟΝ ΜΕΝ ΑΕΡΑ ΔΝΟΦΕΡΟΝ (ΖΟΦΕΡΟΝ) ΚΑΙ ΒΑΡΥΝ ΑΣΘΕΝΕΙΑ ΤΗΣ ΔΙΑΚΡΙΝΟΥΣΗΣ ΑΥΤΟΝ ΑΛΕΑΣ ΕΠΙΦΕΡΕΣΘΑΙ ΤΟΥΣ ΔΕ ΚΑΡΠΟΥΣ ΗΜΙΠΕΠΤΟΥΣ ΚΑΙ ΑΤΕΛΕΙΣ ΑΠΑΝΘΗΣΑΙ ΚΑΙ ΠΑΡΑΚΜΑΣΑΙ ΔΙΑ ΤΗΝ ΨΥΧΡΟΤΗΤΑ ΤΟΥ ΠΕΡΙΕΧΟΝΤΟΣ (ΑΕΡΟΣ)»

ΠΛΟΥΤΑΡΧΟΥ ΒΙΟΙ ΠΑΡΑΛΛΗΛΟΙ: ΚΑΙΣΑΡ
ΤΟΜΟΣ ΚΖ', 69, ΜΕΤΑΦΡ. Α.Ι. ΠΟΥΡΝΑΡΑ, ΠΑΠΥΡΟΣ, ΑΡ. 426

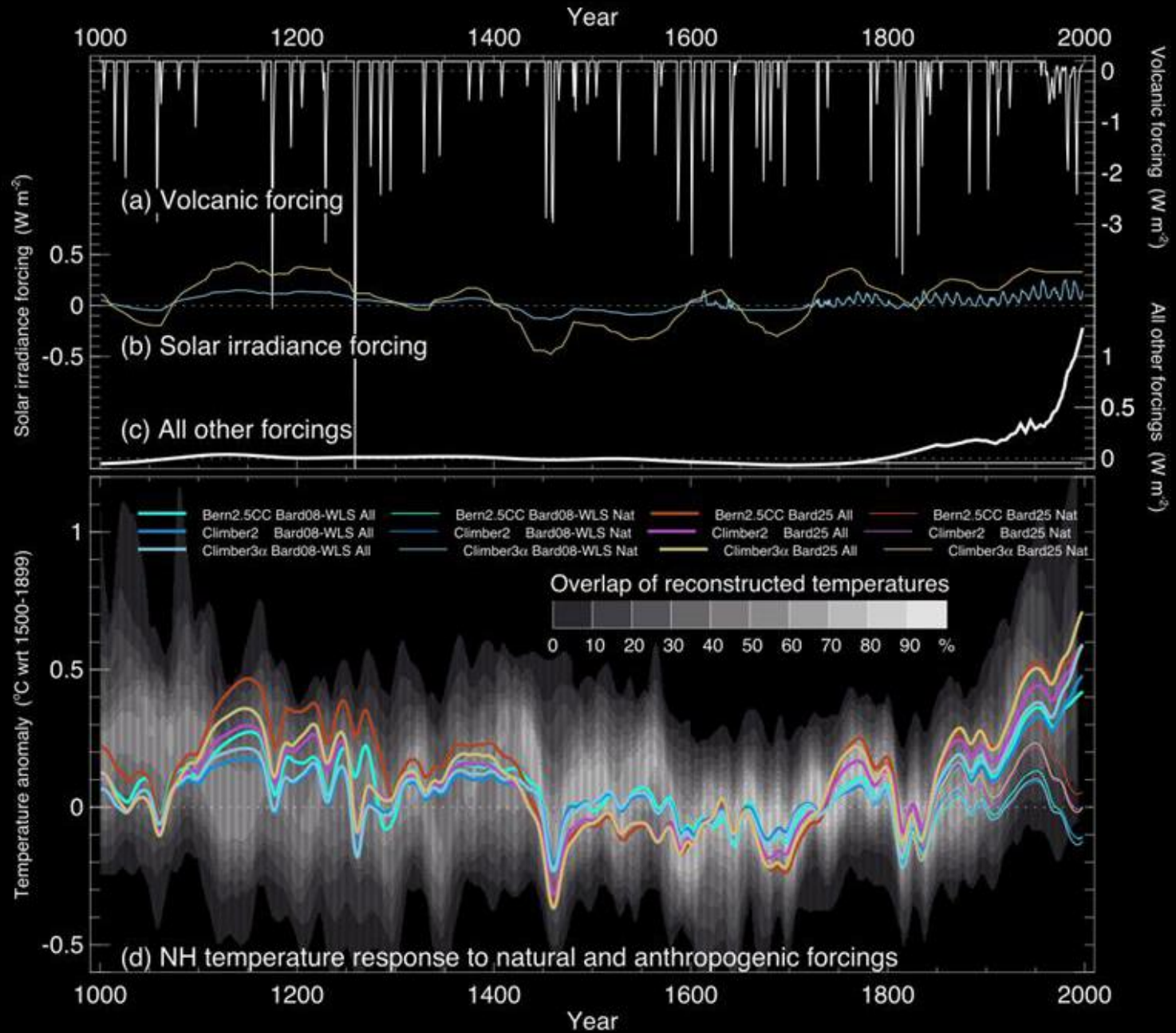
The volcano Tambora, in 1815, created the «Year Without Summer» (1816)



“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; . . .*

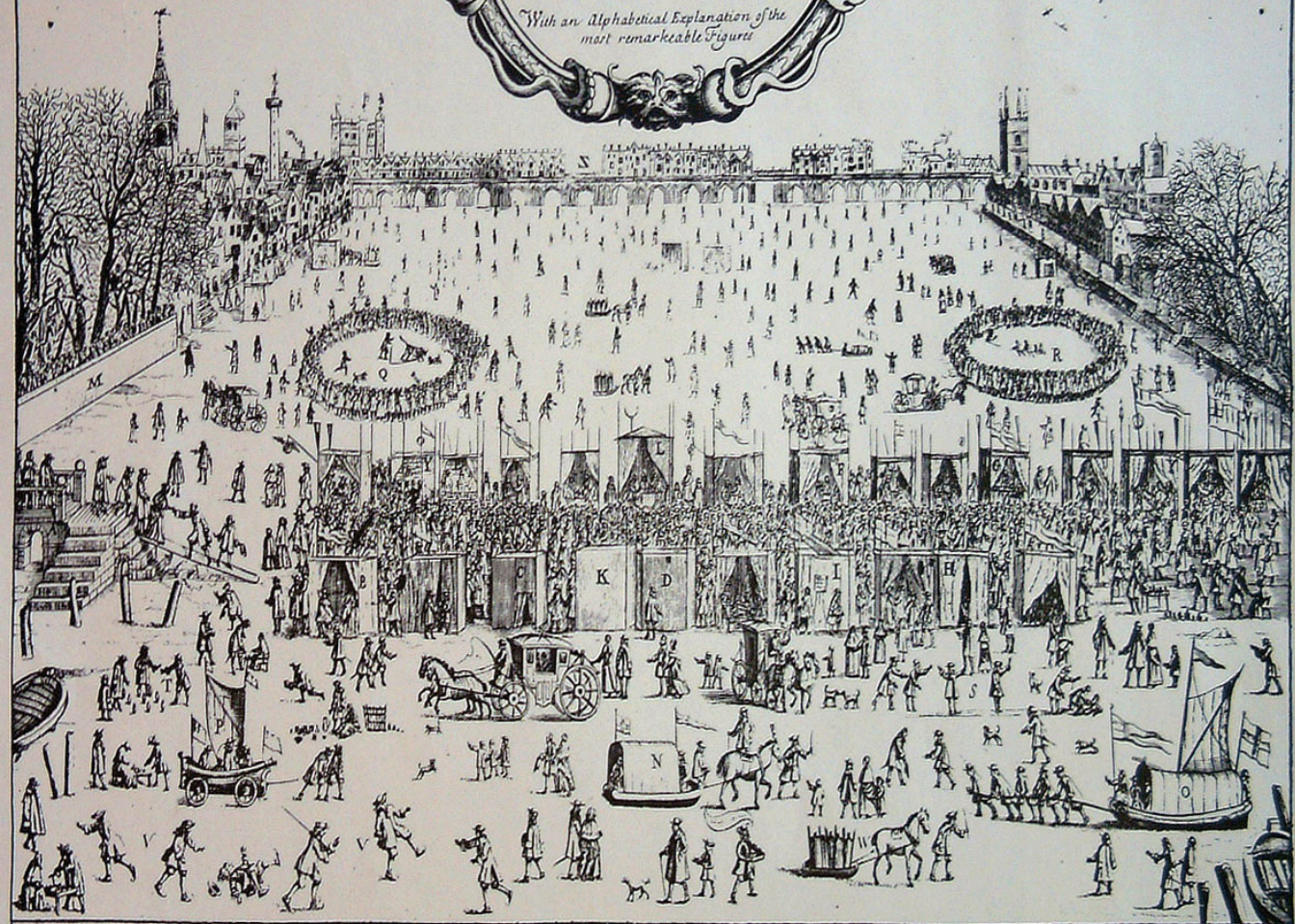
Volcanic aerosols improve our knowledge of the climate of the past





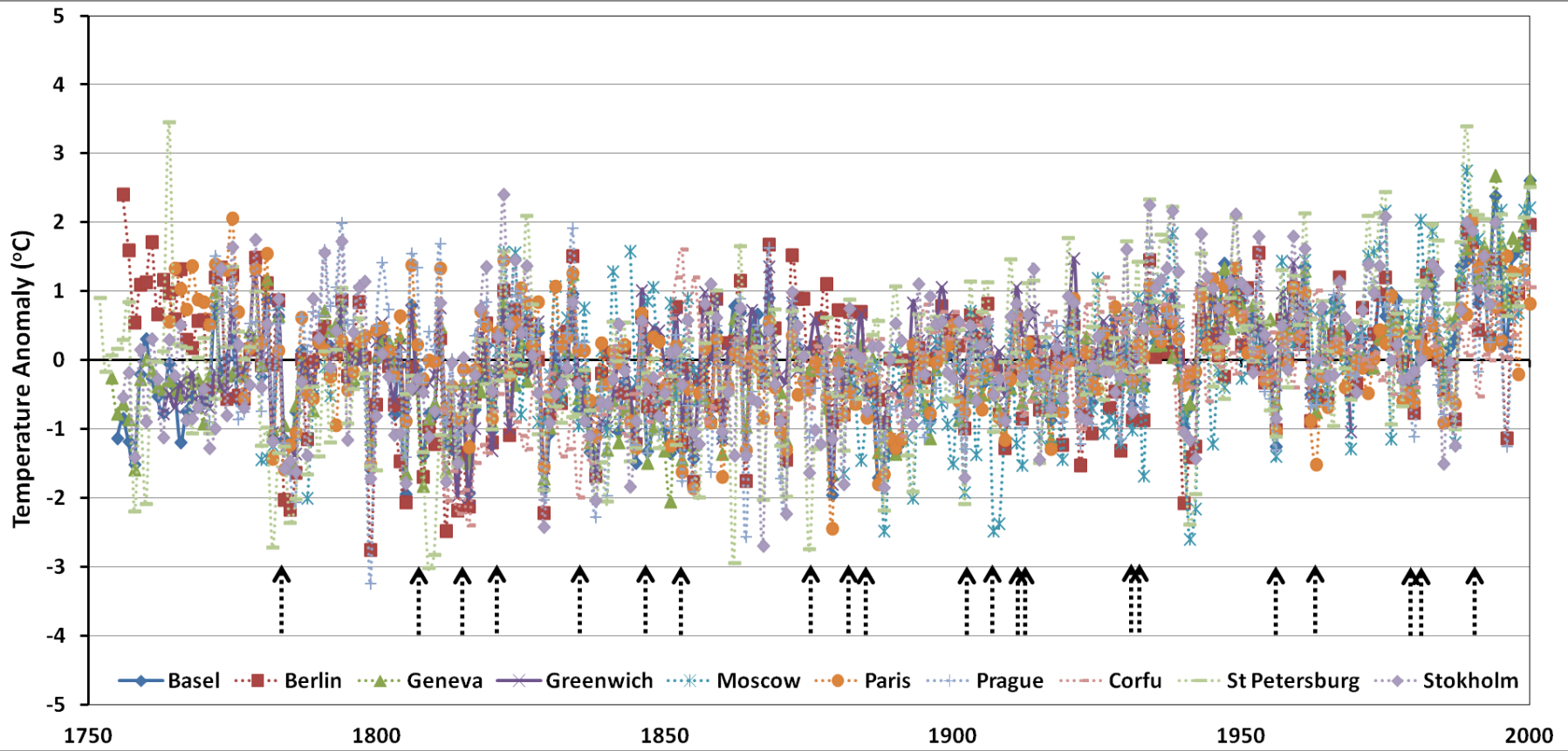
Frozen Thames 1677

AN
 Exact and lively Mapp
 OF
 REPRESENTATION
 Of Booths and all the varieties of Shows and
 Humours upon the ICE on the River of
 THAMES by LONDON
 During that memorable Frost in the 35th year
 of the Reigne of his sacred Ma^{ty}
 King CHARLES the 2^d
 Anno Dⁿⁱ MDCLXXXIII.
 With an Alphabetical Explanation of the
 most remarkable Figures



The Temple stairs with People going upon the Ice to Temple street. A. The Duke of York's Coffee house. B. The Toy Booth. C. The Booth with a Phoenix on it and Insured as long as the Foundation stand. D. The Roast Beef Booth. E. The half way house. F. The Bears garden Shire Booth. G. The Musick Booth. H. The Printing Booth. I. The Lettery Booth. K. The Horse Tavern Booth. L. The Temple garden with Crows of People looking over the wall. M. The Boat drawn with a Horse. N. The Drum Boat. O. The Boat drawn upon wheels. P. The Bull building. Q. The Chair sitting in the Boat. R. The Boat drawn with a Horse. S. The Boat drawn with a Horse. T. The Boat drawn with a Horse. U. The Boat drawn with a Horse. V. The Boat drawn with a Horse.

Annual mean temperatures at ten European sites with long term records



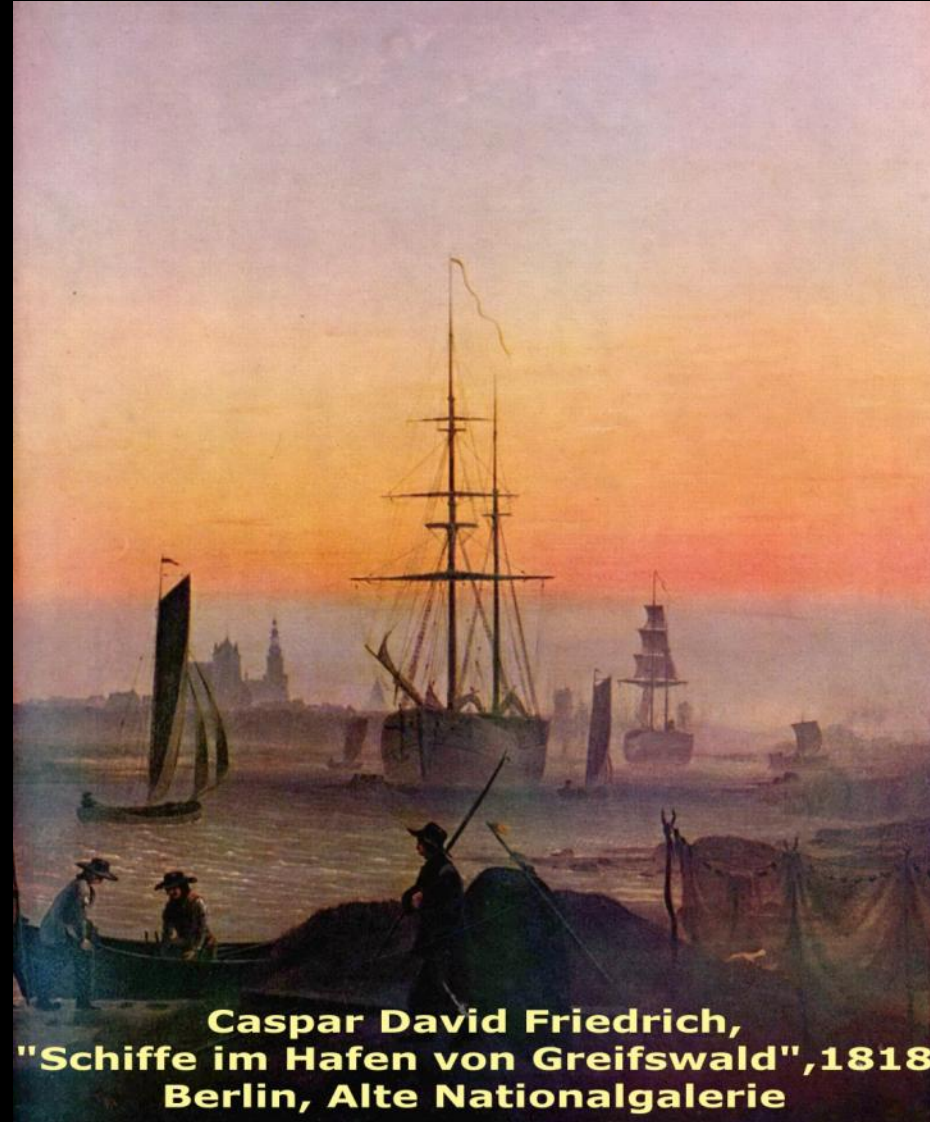
The chromatic understanding of the artist changes after the eruption of Tambora in 1815, and returns to normal levels after a few years

1817: 2 years after Tambora



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

1818: 3 years after Tambora



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

Friedrich Caspar David (1774-1840)

Sunset after Tambora



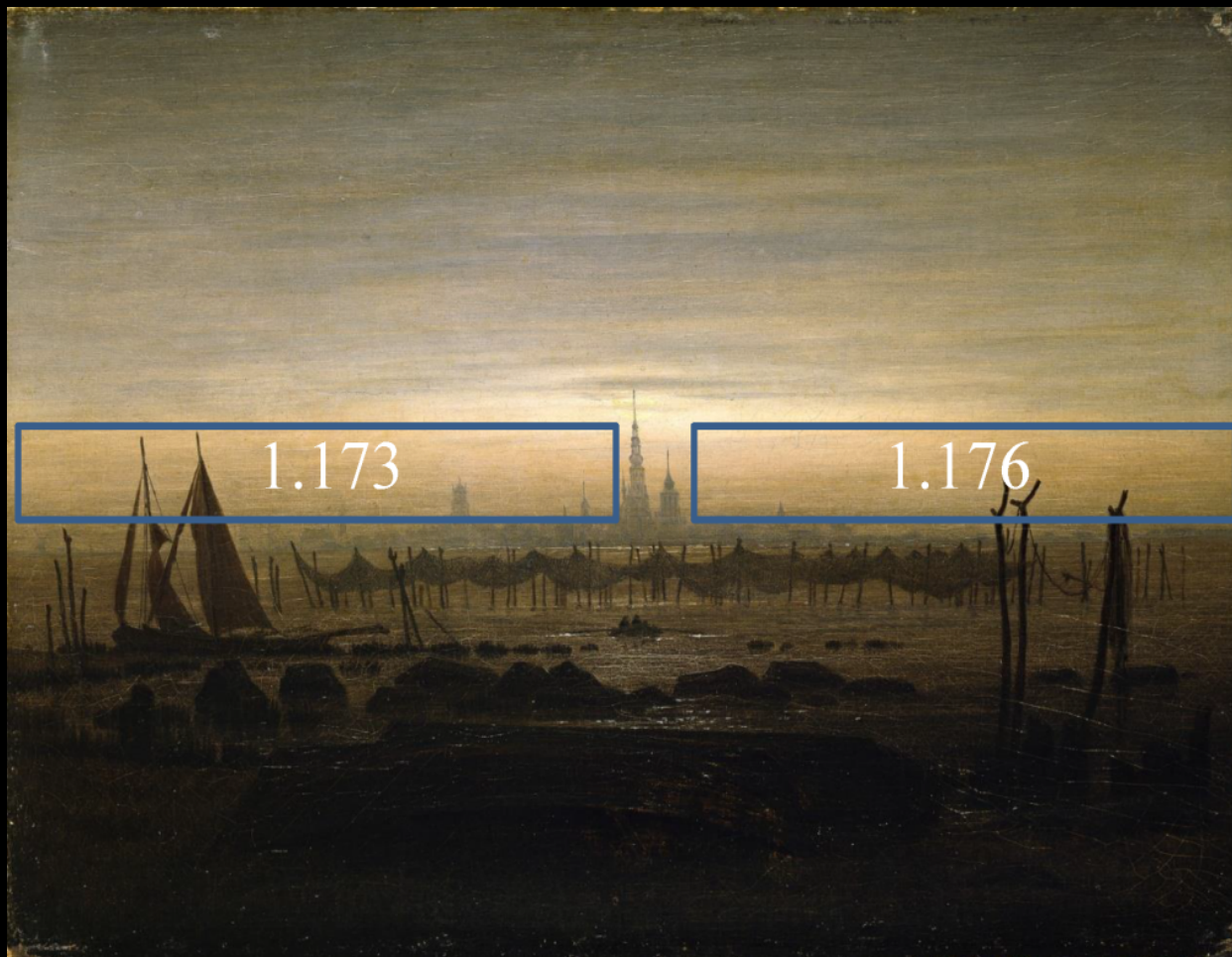
“Woman in front of the Setting Sun”, 1818, Museum Folkwang, Essen, Γερμανία

Sunset without volcano



“Evening”, 1824, Kunsthalle, Mannheim, Γερμανία

R/G ratios with and without structural differences after Tambora (1815)



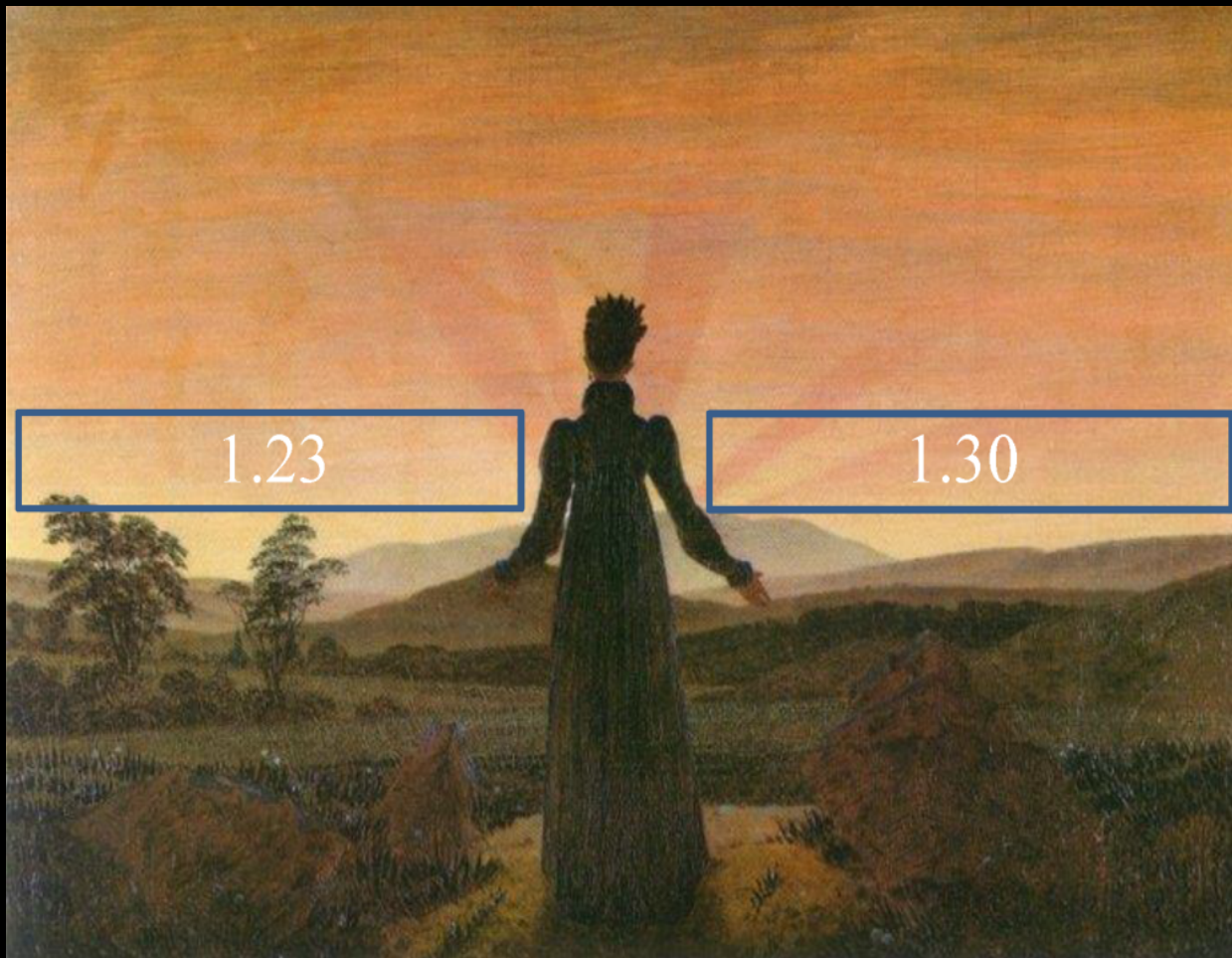
Caspar David Friedrich, *Griefswald in the Moonlight*, 1817.
Corresponding R/G ratios were averaged inside each box.

R/G ratios with and without structural differences after Tambora (1815)



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

R/G ratios with and without structural differences after Tambora (1815)



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

R/G ratios with and without structural differences after Tambora (1815)



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

1810
R/G ratio = 1.021
AOD \approx 0.22

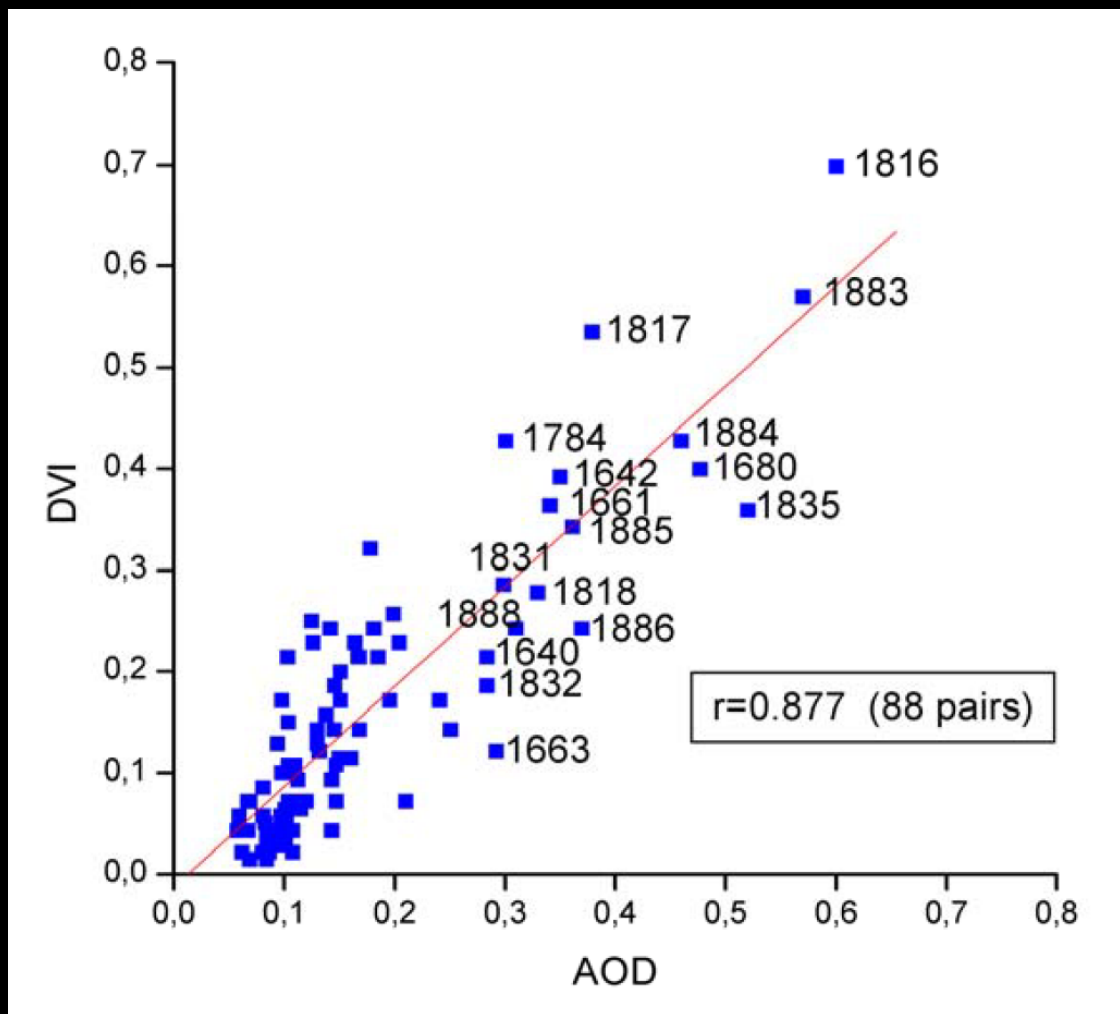


Plate 20 John Constable, *The River Stour at Sunset*, 1809. Private collection

1809
R/G ratio = 1.137
AOD \approx 0.30

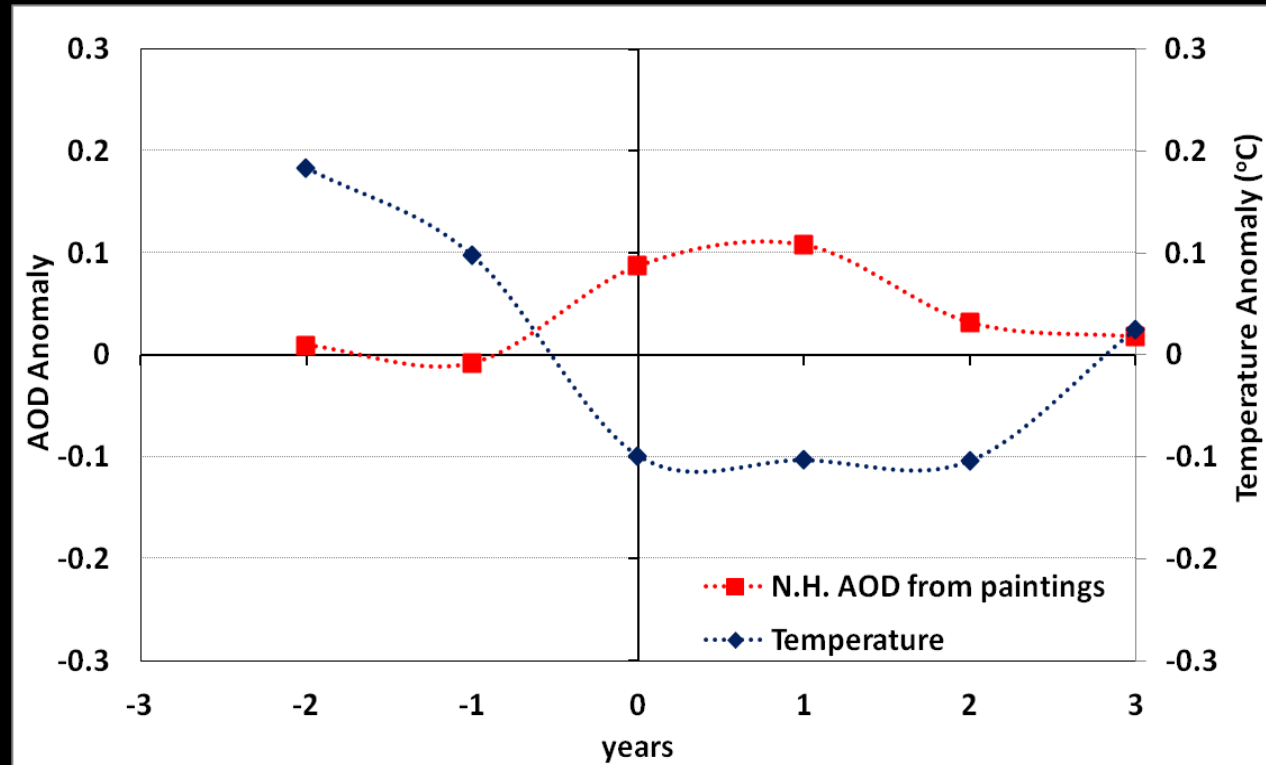
Thornes, J.E., "John Constable's Skies: A Fusion of Art and Science", University Press, 1999

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 eruption with VEI ≥ 5 for AOD and Temperature

No	Volcano (eraption)	Year	VEI
1	Laki	1783	6
2	Mystery 1809 Mega-eruption	1808	6
3	Mount Tambora (1815 eruption)	1815	7
4	Galunggung	1822	5
5	Cosiguina	1835	5
6	Mount St. Helens	1847	5
7	Shiveluch	1854	5
8	Askja	1875	5
9	Krakatoa	1883	6
10	Mount Tarawera	1886	5
11	Santa María	1902	6
12	Ksudach	1907	5
13	Novarupta	1912	6
14	Colima	1913	5
15	Cerro Azul	1932	5
16	Kharimkotan	1933	5
17	Bezymianny	1955	5
18	Mount Agung	1963	5
19	Mount St. Helens	1980	5
20	El Chichón	1982	5
21	Mount Pinatubo	1991	6
22	Mount Hudson	1991	5

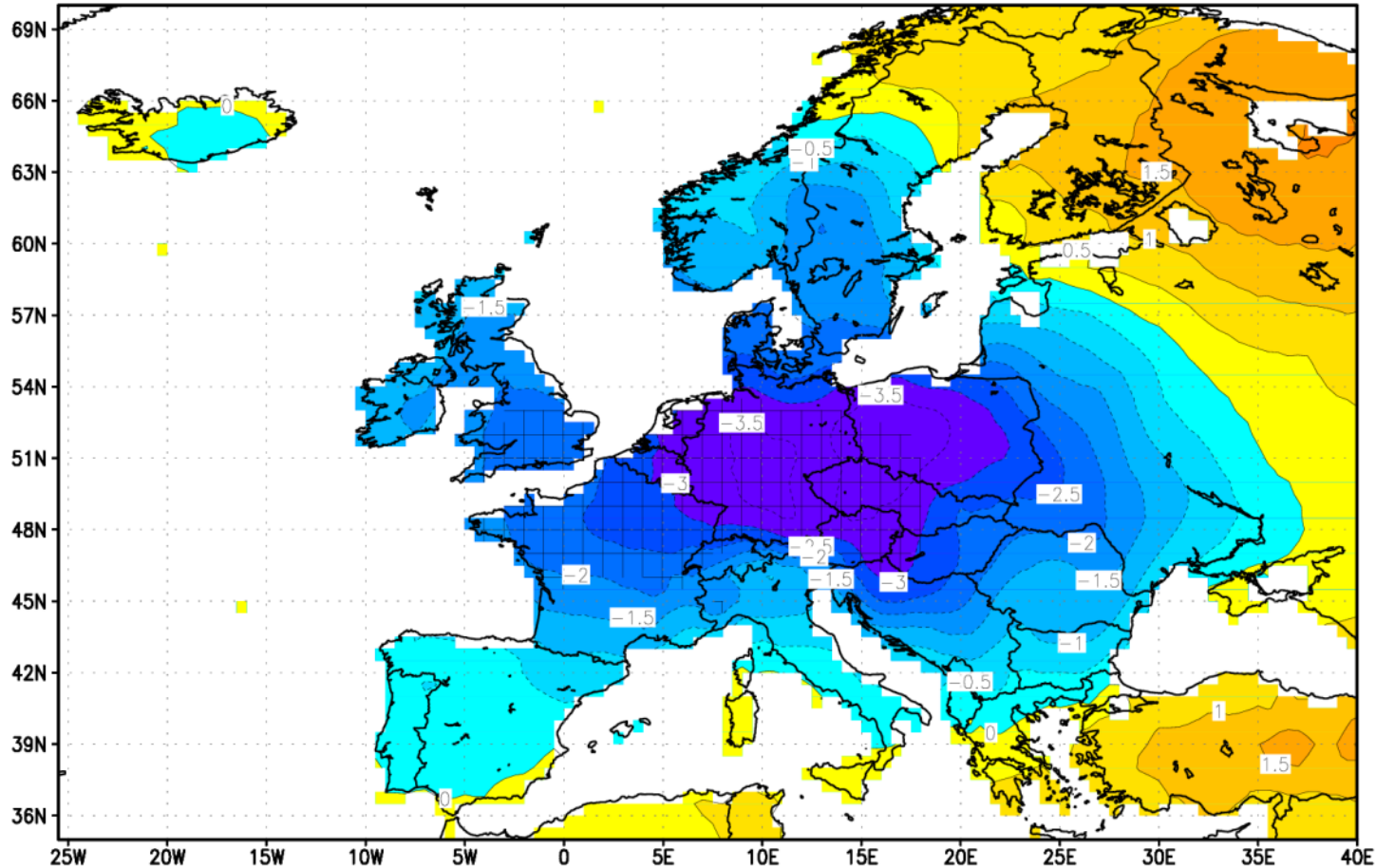


Climatic stations: Basel, Berlin, Geneva, Greenwich, Moscow, Paris, Prague, Corfu, St Petersburg, Stockholm

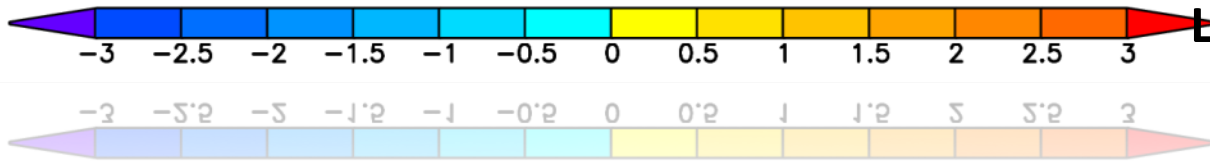
The active volcano Laki in Iceland



DJF 1783–1784 Temperature Anomaly (°C)



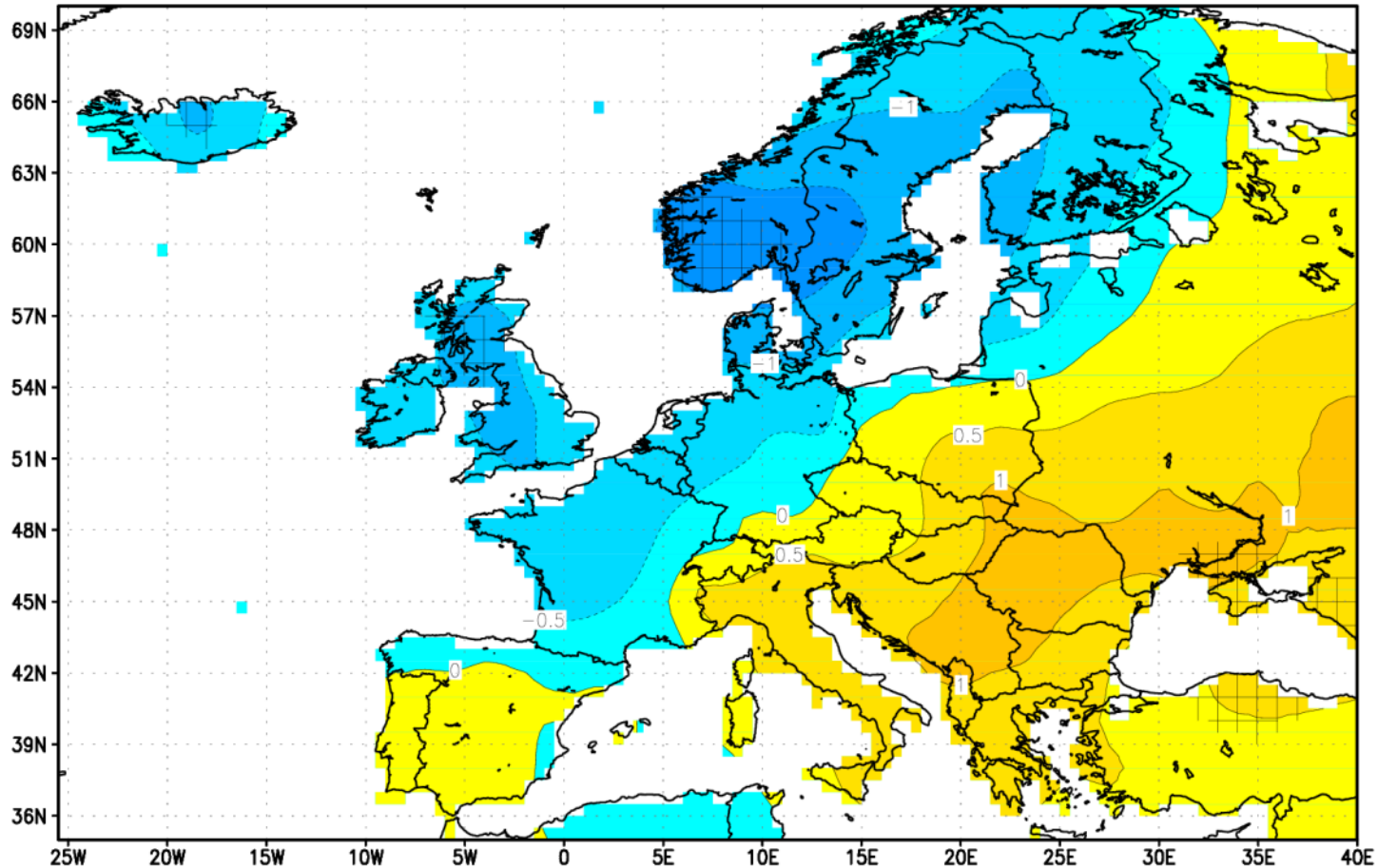
Significant
at 90% level



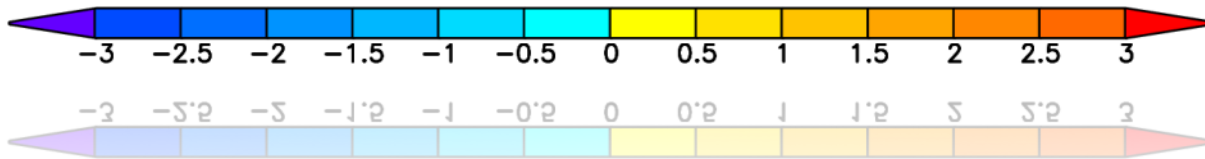
Luterbacher et al.
(2004)

32W 30W 28W 26W 24W 22W 20W 18W 16W 14W 12W 10W 8W 6W 4W 2W 0 2E 4E 6E 8E 10E 12E 14E 16E 18E 20E 22E 24E 26E 28E 30E 32E 34E 36E 38E 40E

JJA 1784 Temperature Anomaly (°C)

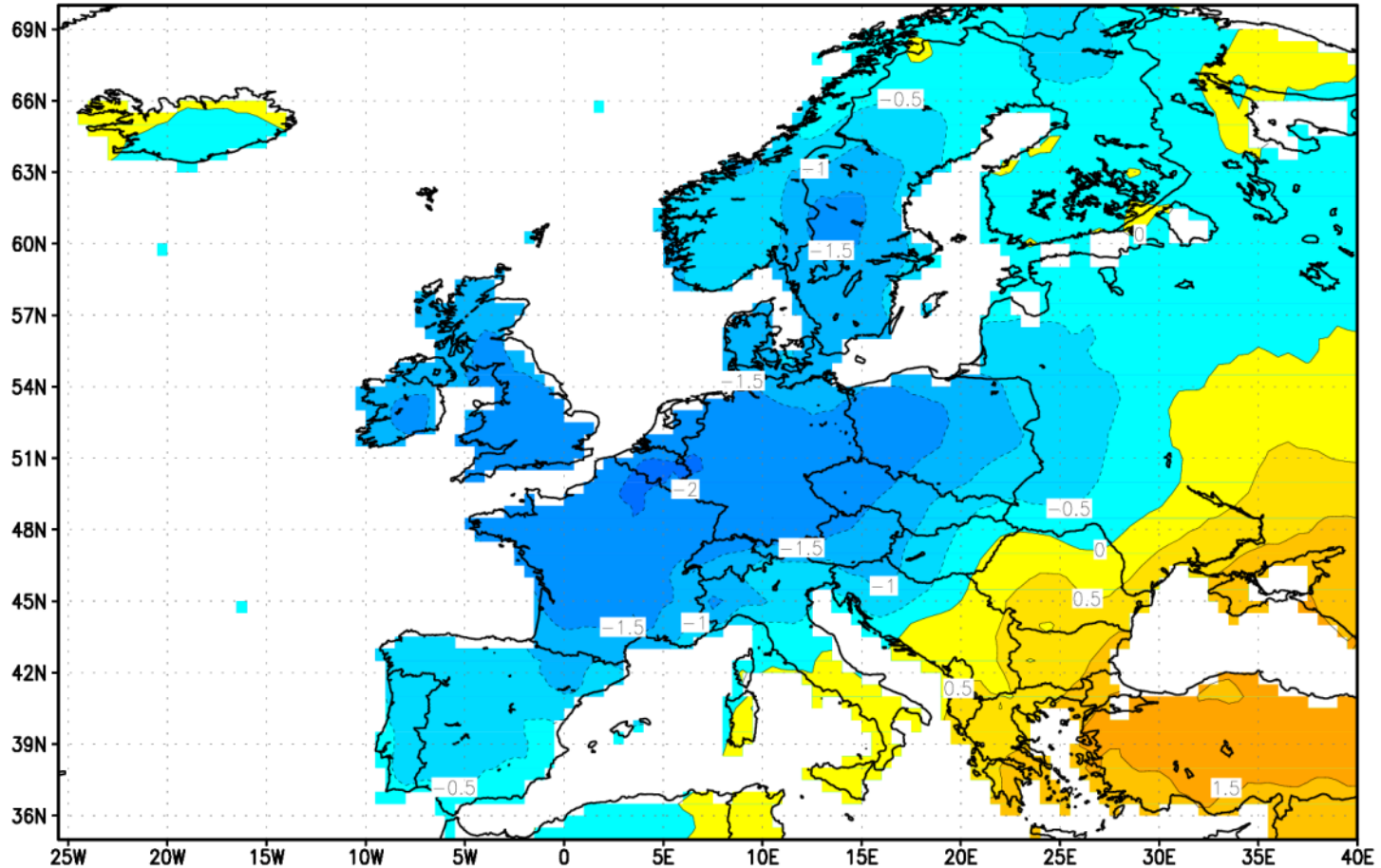


Significant
at 90% level

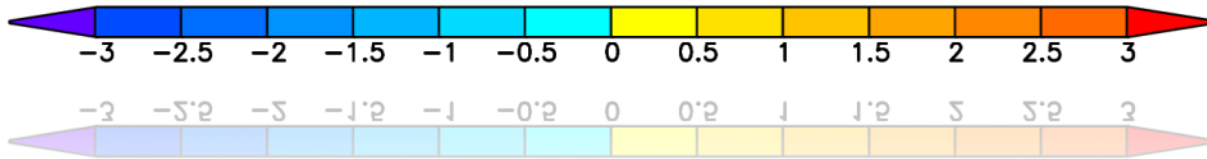


32W 30W 28W 26W 24W 22W 20W 18W 16W 14W 12W 10W 8W 6W 4W 2W 0 2E 4E 6E 8E 10E 12E 14E 16E 18E 20E 22E 24E 26E 28E 30E 32E 34E 36E 38E 40E

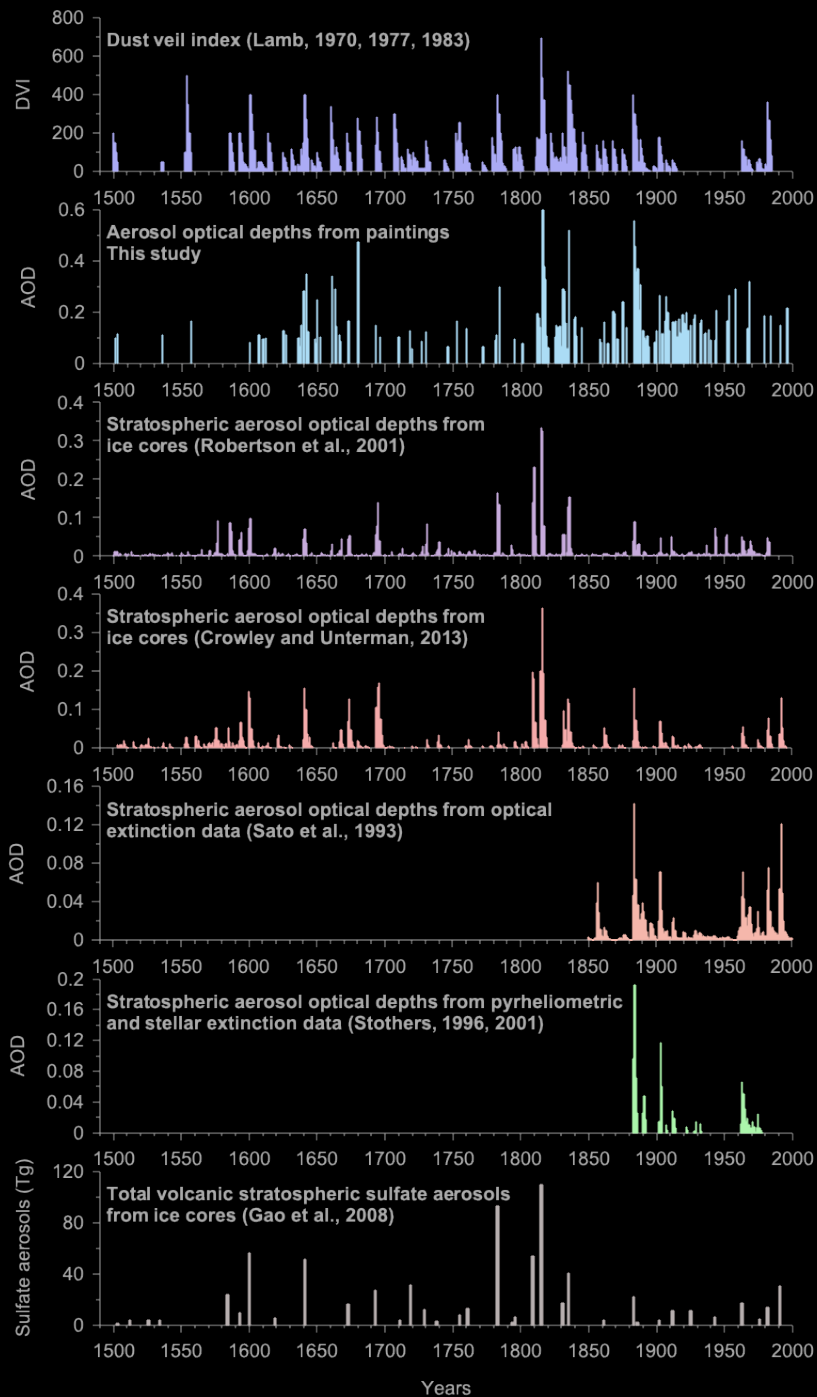
DJF 1784–1785 Temperature Anomaly (°C)



Significant
at 90% level



32W 30W 28W 26W 24W 22W 20W 18W 16W 14W 12W 10W 8W 6W 4W 2W 0 2E 4E 6E 8E 10E 12E 14E 16E 18E 20E 22E 24E 26E 28E 30E 32E 34E 36E 38E 40E



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)

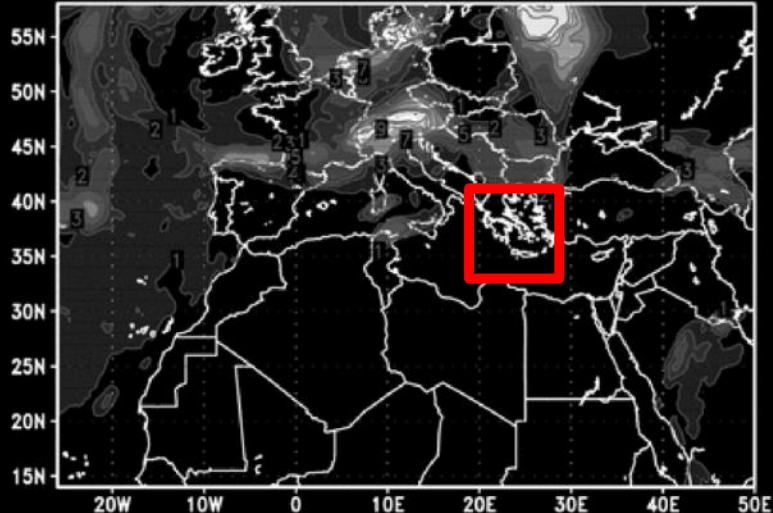


Upper: Digitally compressed paintings by P. Tetsis at the Hydra experiment under higher (left panel) and lower (right panel) AOD conditions. Bottom: Digital camera photos of the landscape.

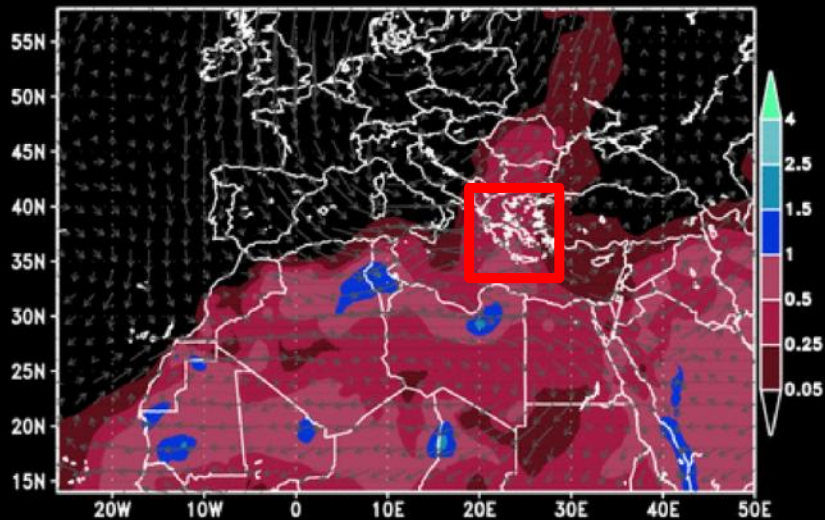
Passage of a Saharan dust event

<http://www.bsc.es/projects/earthscience/DREAM>

BSC-DREAM8b Total Cloud Cover
6h forecast for 18z 19 JUN 10

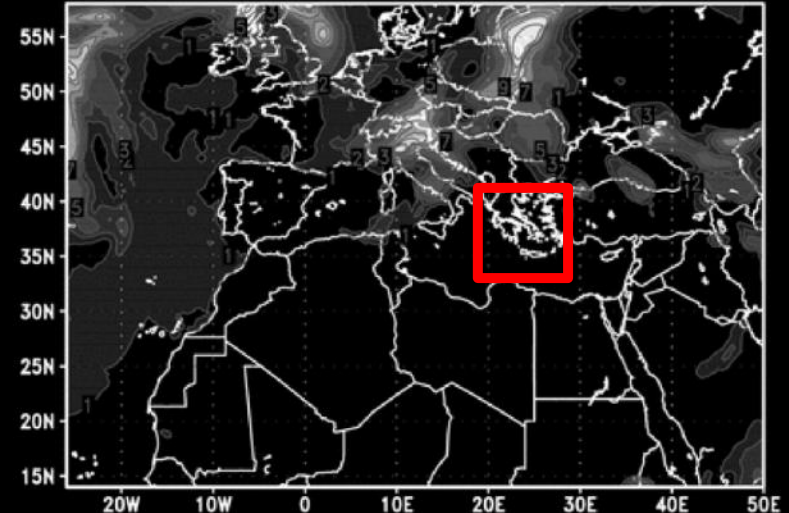


BSC-DREAM8b Dust Loading (g/m^2) and 3000m Wind
6h forecast for 18z 19 JUN 10

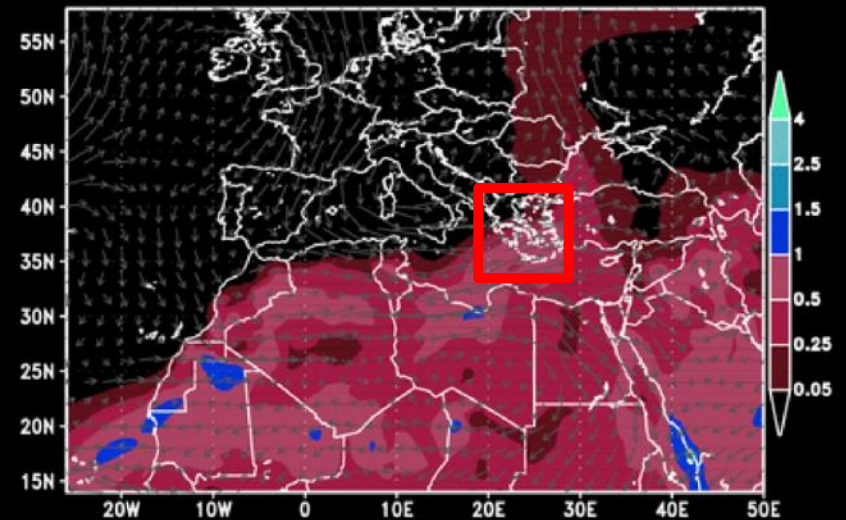


<http://www.bsc.es/projects/earthscience/DREAM>

BSC-DREAM8b Total Cloud Cover
6h forecast for 18z 20 JUN 10

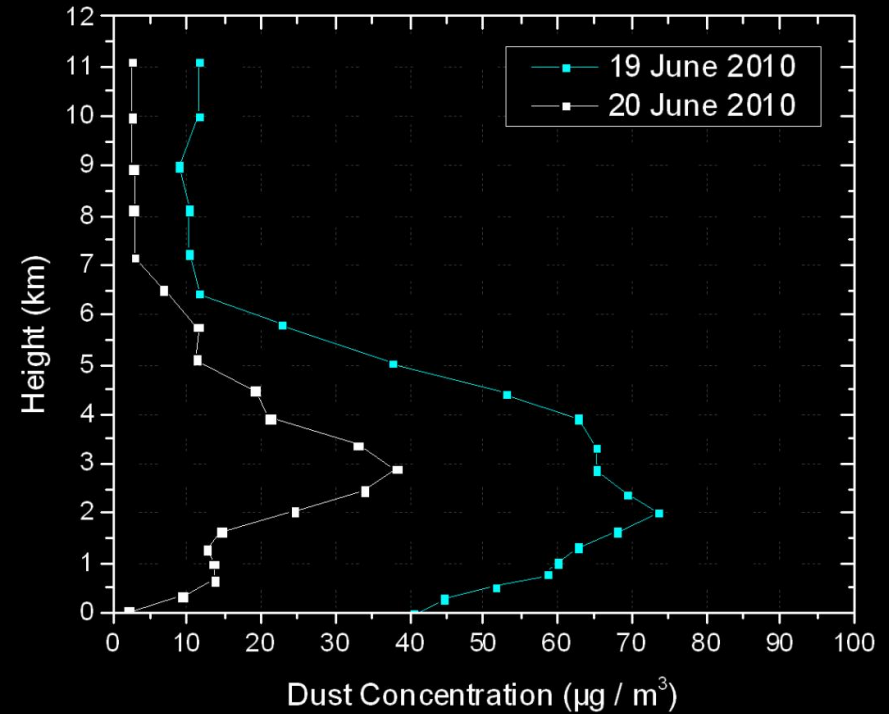
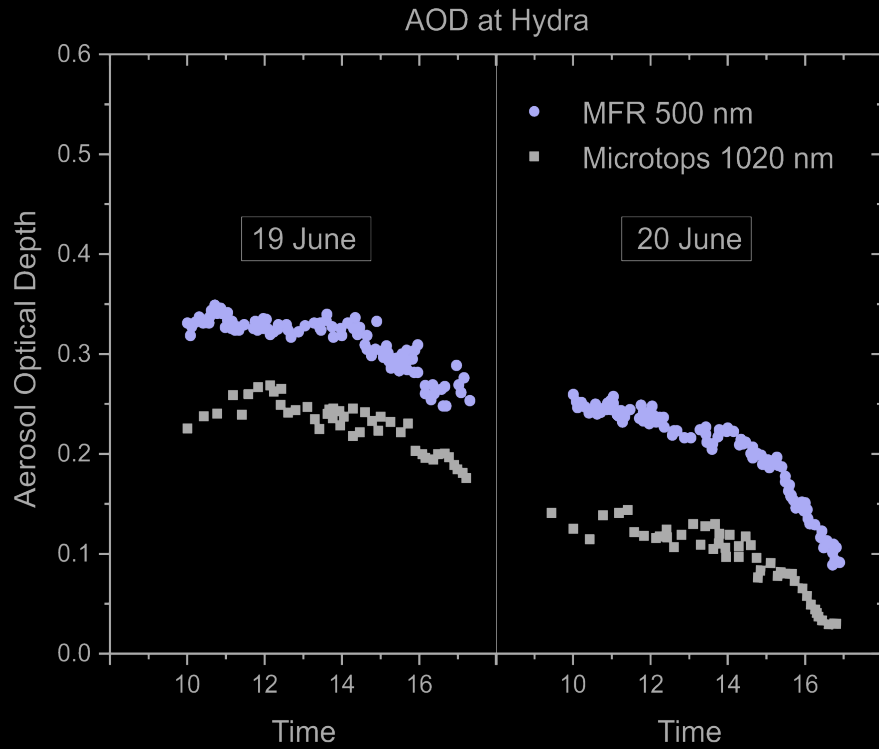


BSC-DREAM8b Dust Loading (g/m^2) and 3000m Wind
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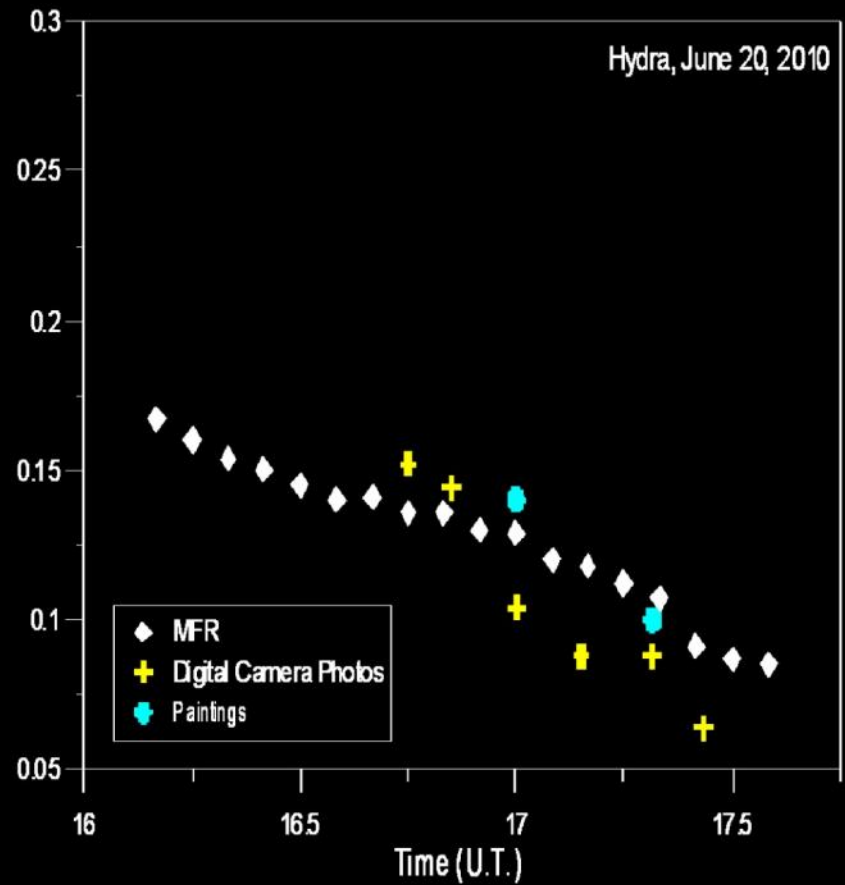
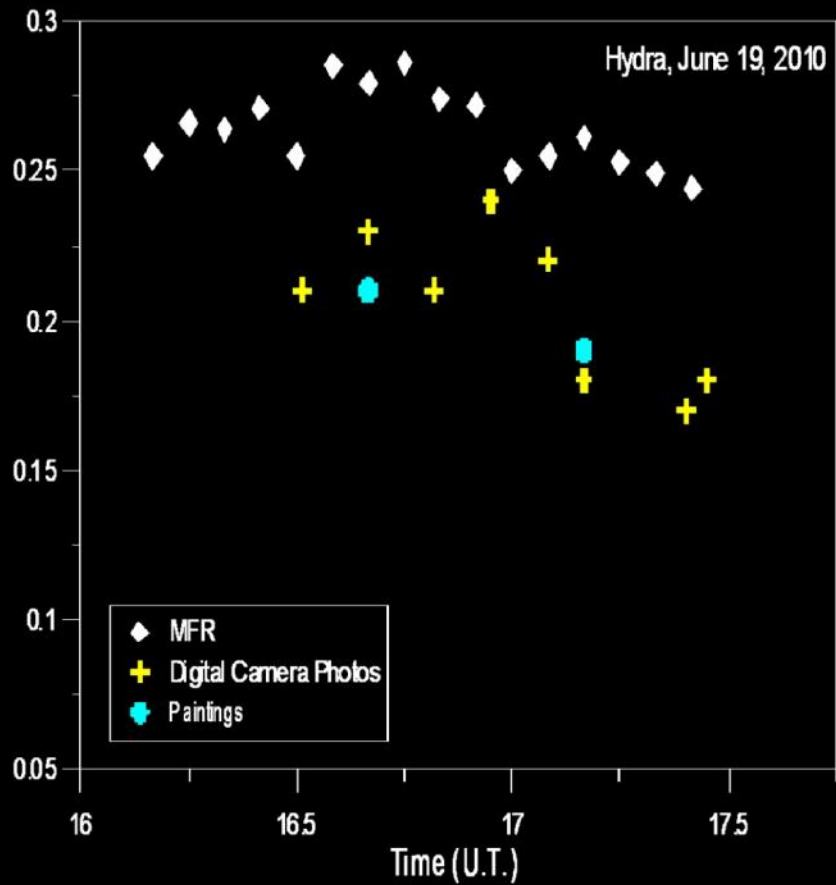


MFR-7 AOD retrievals at 500 nm on 19 and 20 June 2010 at Hydra campaign site. Microtops II AOD retrievals at 1020 nm are superimposed

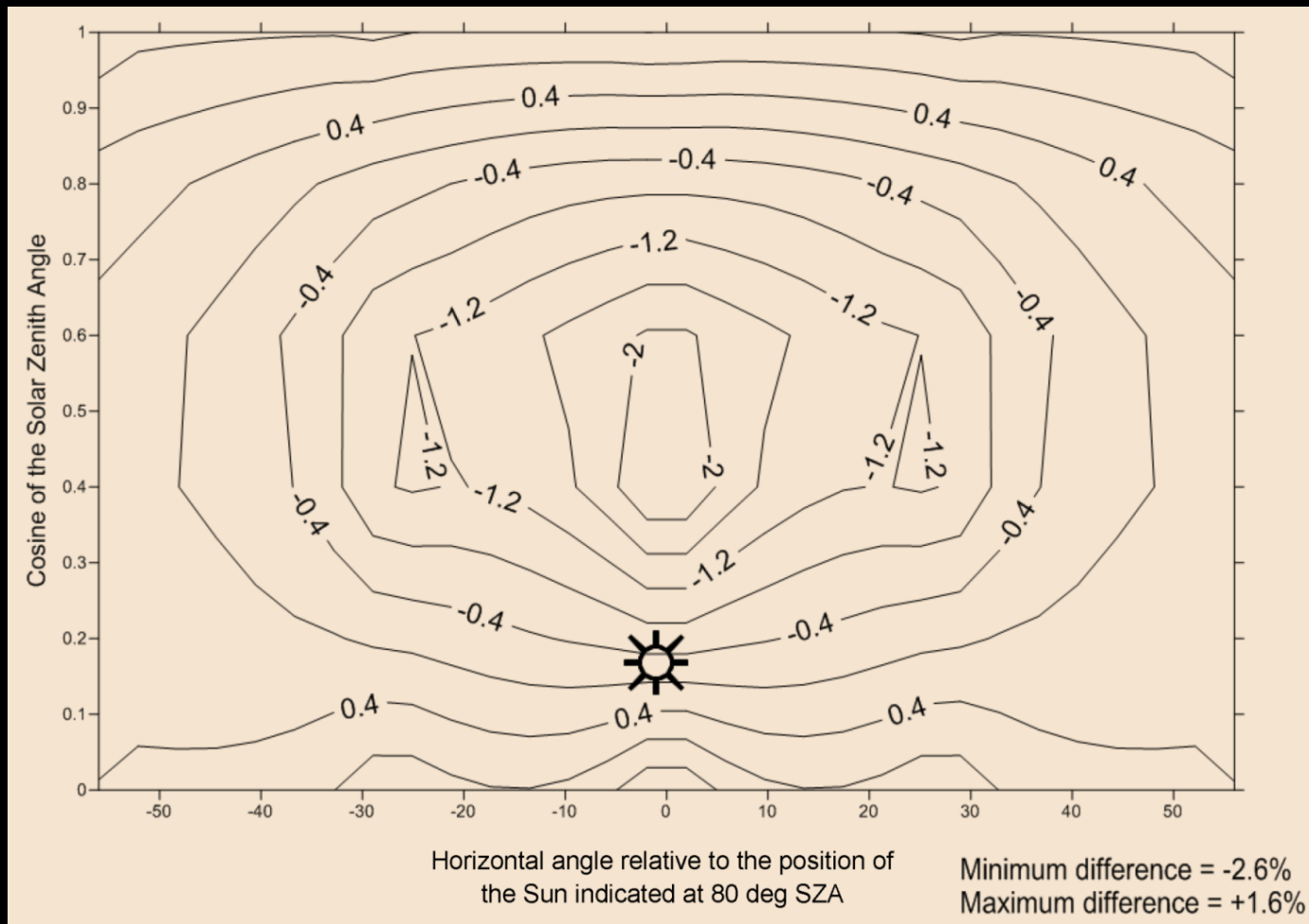
The profile of Saharan dust



Aerosol measurements during the two days of the experiment

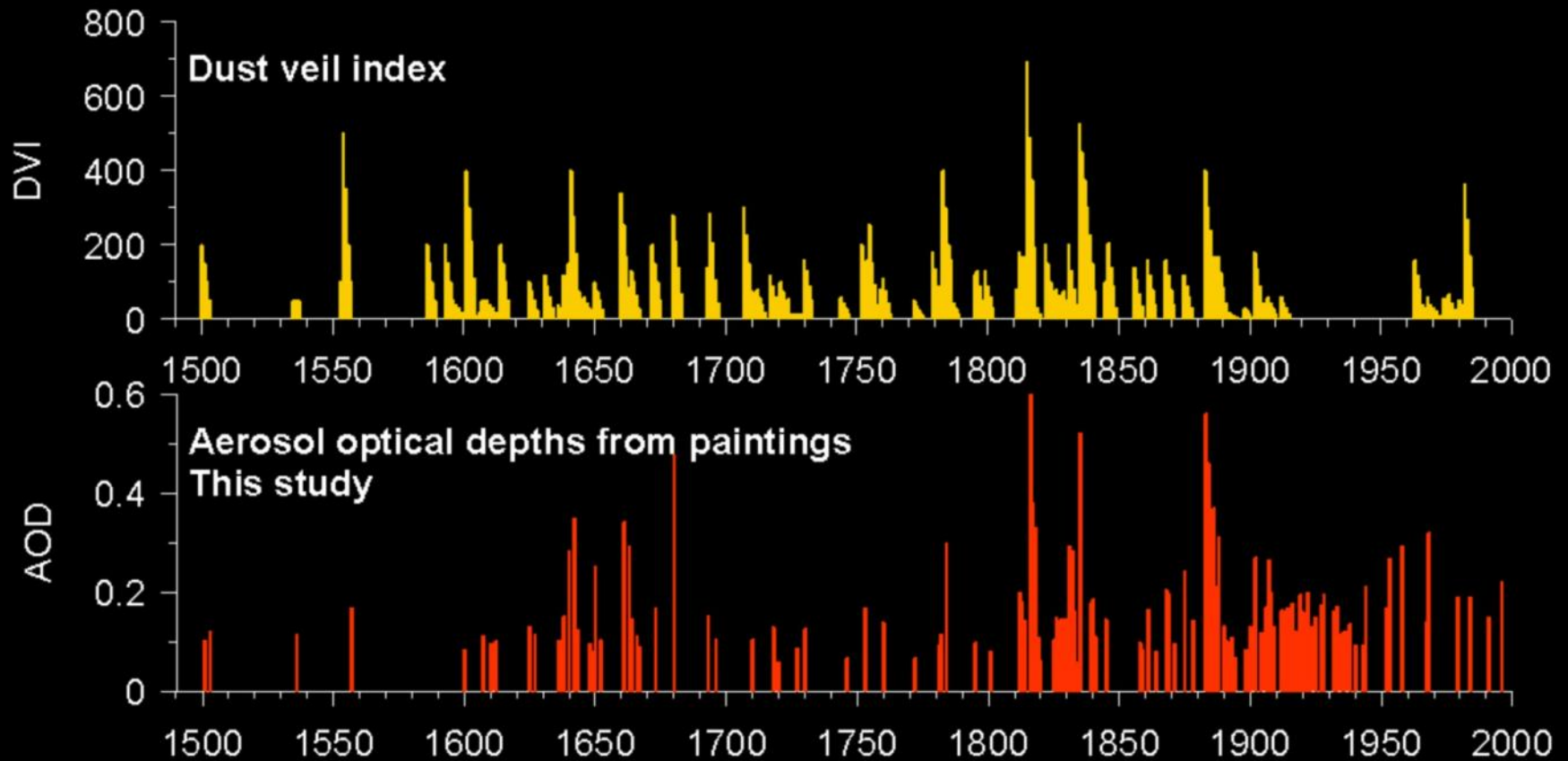


Percent difference in R/G ratios between the measured at Hydra Sahara dust mineral aerosol profile and a typical modelled volcanic aerosol profile. In both cases AOD (500 nm) was set to 0.25.



(DVI) Independent index of volcanic aerosols.

(AOD) Absorption of solar radiation in the atmosphere from measurements in paintings.



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 Guardian
- Monday October 1 2007

The British Heritage journal 2007 Turner said that work was not in evidence of the 'the dark afterglow of a winter night' - first global warming experiment

Volcanic eruptions are helping scientists to understand the impact of climate change on the planet

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RESEARCH HIGHLIGHTS

Volcanic paintings

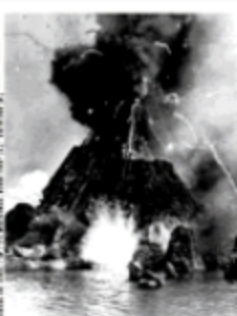
Atmos. Chem. Phys. 7, 4027-4042 (2007)
 The ash from large volcanic eruptions can cool Earth's climate and cause vivid red sunsets. But the historical effects of volcanic activity on climate are difficult to quantify owing to a lack of direct atmospheric observation.

Charitos Zerefos at the Academy of Athens in Greece and colleagues have come up with a novel way to quantify the amount of volcanic ash in the atmosphere. They analysed particle content in middle latitudes isotherms during the period 1500-1800 sunsets captured in paintings by J.M.W. Turner, Edgar Degas and others. They found that the red/green colour ratios from the paintings were consistent with those calculated from direct observations of volcanic eruptions such as 1680 and 1883. The team then used this to reconstruct how much light was blocked by ash in the air. The resulting time series could complement existing data on atmospheric composition.



DER SPIEGEL 41/2007

Wissenschaft · Technik



Marsch-Gemälde „Der Schmerz“ Ausbruch des Kubaetau (1813)

Klima-Archiv in der Galerie

Caspar David Friedrich, Edgar Degas oder Willem Turner sahen Sonnenaufgänge in überwältigenden Farben. Jetzt bekommen ihre Gemälde

neue Bedeutung. Forscher haben festgestellt, dass die in den Gemälden gezeigten Sonnenfarben auf die Auswirkungen von Vulkaneruptionen zurückzuführen sind. Die Forscher haben festgestellt, dass die in den Gemälden gezeigten Sonnenfarben auf die Auswirkungen von Vulkaneruptionen zurückzuführen sind.

AP Associated Press
 NATIONAL GEOGRAPHIC
 The Washington Times
 THE HINDU
 Art as Window to Climate Change
 Kate Schuman, Associated Press, Nov. 29, 2007

Μελέτησαν τα ηλιοβασίλεματα

Τετάρτη, 03/10/07

Επίσης, οι ερευνητές έχουν ανακαλύψει ότι οι ηλιοβασίλεματα που απεικονίζονται στα έργα των Turner, Degas και άλλων ζωγράφων του 19ου αιώνα, δείχνουν ότι οι ηλιοβασίλεματα ήταν πιο συχνά κόκκινα από ό,τι θα ήταν σε μια κανονική ηλιοβασίλεμα.

ΕΛΕΥΘΕΡΟΤΥΠΙΑ
 Ζωγραφίζοντας το κλίμα
 Του ΒΛΑΔΙΜΙΡ ΚΑΪΤΑΖΗ, 05-10-2007
 Με αυτή την έρευνα κερδίζει τον ανταγωνισμό οριστική, ο οποίος ο κατανοεί την ιστορία των αλλαγών στο κλίμα.



ΤΟ ΒΗΜΑ

28-11-2007
 Ζητήματα και κλιματικές αλλαγές
 ΔΟΞΙΜΟ: Επιστήμονες από 500 θέσεις διερευνούν τη σχέση μεταξύ των ηλιοβασιλέματων που απεικονίζονται στα έργα των Turner, Degas και άλλων ζωγράφων του 19ου αιώνα, και των ηλιοβασιλέματων που απεικονίζονται στα έργα των Turner, Degas και άλλων ζωγράφων του 19ου αιώνα.

Süddeutsche Zeitung

Klima auf der Leinwand

Aus alten Gemälden kann man einiges lernen. Dass sie auch die Klimagefährliche abbilden, ist neu: Edwin Seligson waren gelbe Chronisten historischer von Axel Bogdanow, 12-10-2007

THE INDEPENDENT

Art & science: Turner's message from the skies

Research links painter's sunsets to volcanic eruptions
 By Geoffrey Lean
 Sunday, 7 October 2007

It could be that in a brilliant sunset, the sun has just passed behind a volcanic eruption, says a new study.

It is an "orange" sunset, says a new study. The orange is due to volcanic eruptions that have been erupting to cause the impact of volcanic eruptions.

It is a sunset of volcanic eruptions, says the study. The study shows that volcanic eruptions can cause the impact of volcanic eruptions.

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REUTERS

Classic paintings had a helping hand from volcano

Thu Oct 4, 2007 12:10am EDT
 By Karolis Grismann

ATLANTA (Reuters) - Studies of masterpieces from 1850 to 1950 centuries earlier have been that volcanic eruptions had a hand in the dramatic red sunsets seen in the paintings.

The use of color by artists such as J.M.W. Turner, revealed by the dramatic red sunsets seen in the paintings. The use of color by artists such as J.M.W. Turner, revealed by the dramatic red sunsets seen in the paintings.

Turner depicted his "The Rain, Steam, and Great Bridge" in London, which was painted in 1835, after the eruption of Mount Tambora in 1815.

Other notable eruptions that influenced painted sunsets in the 19th century of the volcanic eruptions in the 19th century.

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中外对话 chinadiologue

Old masters, new climate lessons?

David Adam
 November 09, 2007

Paintings of volcanic eruptions had a hand in the dramatic red sunsets seen in the paintings. The use of color by artists such as J.M.W. Turner, revealed by the dramatic red sunsets seen in the paintings.

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the eggs
 E.G.U. NEWSLETTER
 Volcanic eruptions had a hand in the dramatic red sunsets seen in the paintings.

Atmospheric effects of volcanic eruptions as seen by famous artists and depicted in their paintings
 by G. C. Zerefos et al.

und seine Kollegen hat

It is a sunset of volcanic eruptions, says the study. The study shows that volcanic eruptions can cause the impact of volcanic eruptions.

Thank you for your attention!

