HISTORICAL CLIMATE DATA FOR CULTURAL HERITAGE CONSERVATION

C.M. Grossi & P. Brimblecombe

c.grossi-sampedro@uea.ac.uk

University of East Anglia

Stone decay and conservation

STONE: *Building material*

Weathering depends on

Stone:

- Petrography
- Physical properties
- Chemical composition

Environment:

- Climate
- Pollution

Changes: stone adaptation to new conditions

WEATHERING: patina of age

DECAY: Physical - Aesthetical

social context implications: Thresholds

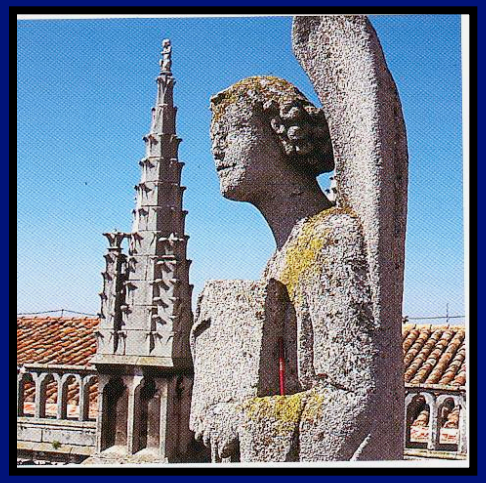
HERITAGE CLIMATOLOGY

Heritage climatology

- **Climatology** science that studies weather averaged over time
- **Heritage Climatology** the study of the climate parameters that affect monuments, materials and sites.

- *The parameters used in heritage climatology differ from those typical in meteorology (e.g. temperature or relative humidity) and focus on cycles and combinations of meteorological parameters that relate to material damage.*

BRIMBLECOMBE (2009) Heritage Climatology



Blackening, frost and salt damage, surface recession, in different points in Europe

Historical data for heritage climatology: CLIMATE

- Climate events from the Bible
- History of climate that covers the period of our architectural heritage: documentary records and instrumental records from recent centuries. ***The particular focus of our interest in areas of human occupation makes documentary observations, especially important.***
- At a very local level is possible to examine climate change at specific buildings (Trajan Column, since AD 105).

BRIMBLECOMBE & CAMUFFO (2002) Long term damage to the built Environment. *Air Pollution Reviews*, v.2, pp: 1-30.

Historical data for heritage climatology: POLLUTION

Urban pollution: known from classical times, burn of wood in Rome: blackened temples. Estimation of changes in pollutant concentration possible by modelling fuel use.

Sources of information: Documentary data, supplemented by pictorial sources (blackening and discolouration).

Modelling: known past concentrations can be used to estimate depositions of pollutants to buildings.

Crust layers analysis: gives data for studying past pollution

BRIMBLECOMBE & CAMUFFO (2002) Long term damage to the built Environment. *Air Pollution Reviews*, v.2, pp: 1-30.

Urban Climate& Pollution Input:

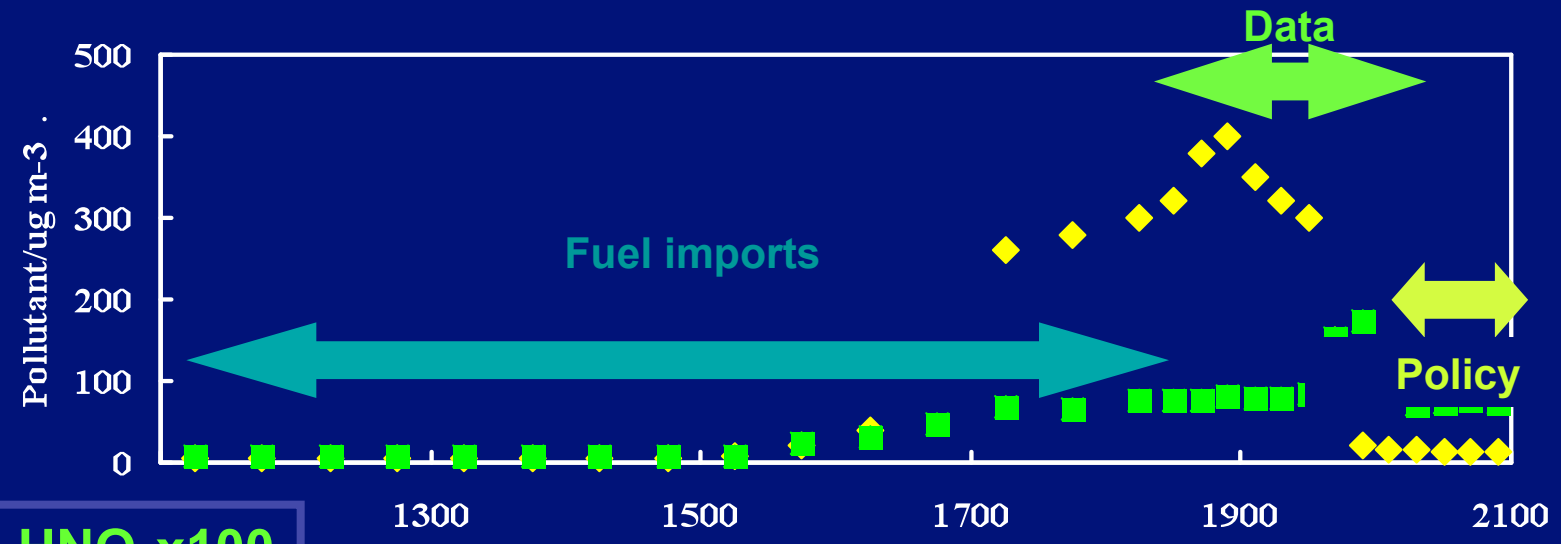
Historical data sets relating to damage

Estimated from Netherlands
van Engelen et al., 2001

Instrumental CETR

HadCM3a2

TEMPERATURE



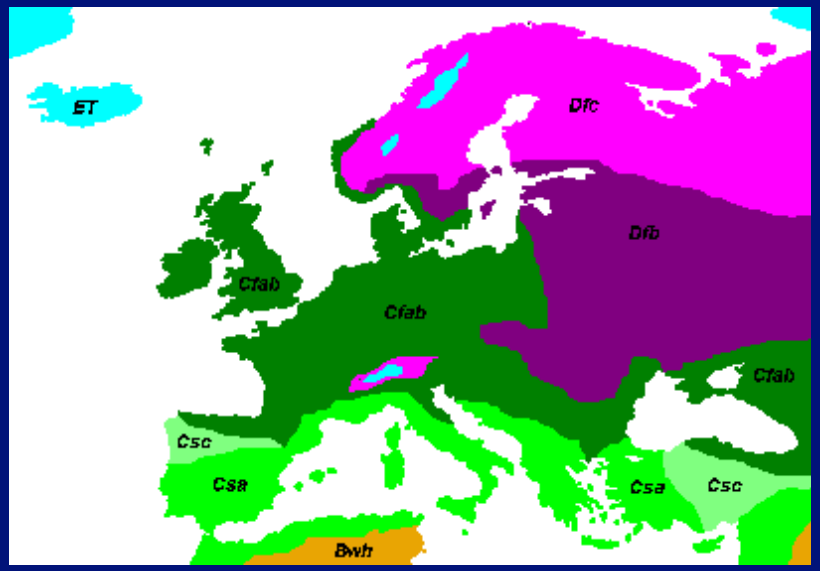
SO_2 & HNO_3x100

BRIMBLECOMBE & GROSSI Millennium-long recession of limestone facades in London *Environmental Geology* 56, 463-471 (2008)

Classical Climatology

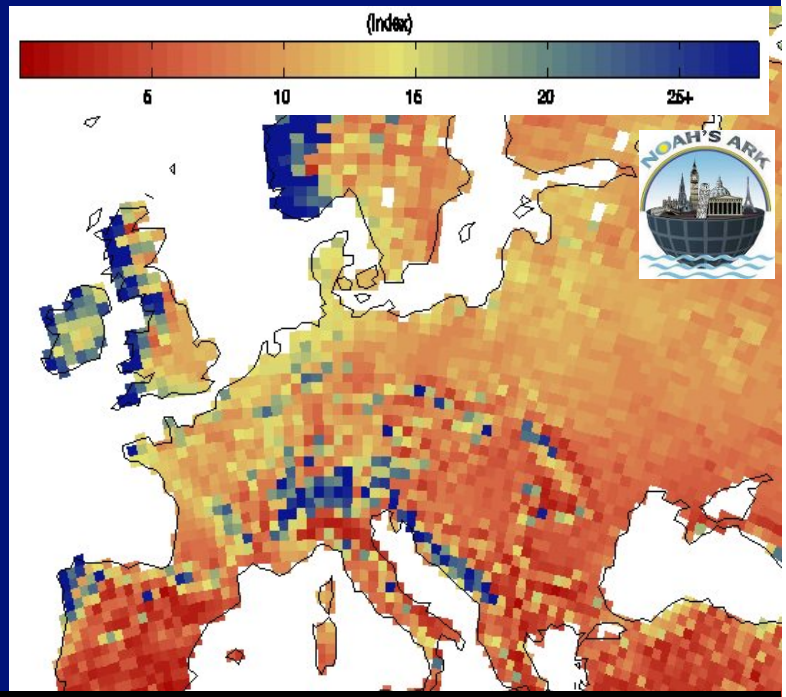
Köppen-Geiger

Vegetation/climate origin



Heritage climatology

For heritage this water-temperature climatology misses out wind etc…



Wind driven rain- high in coastal areas/mountains

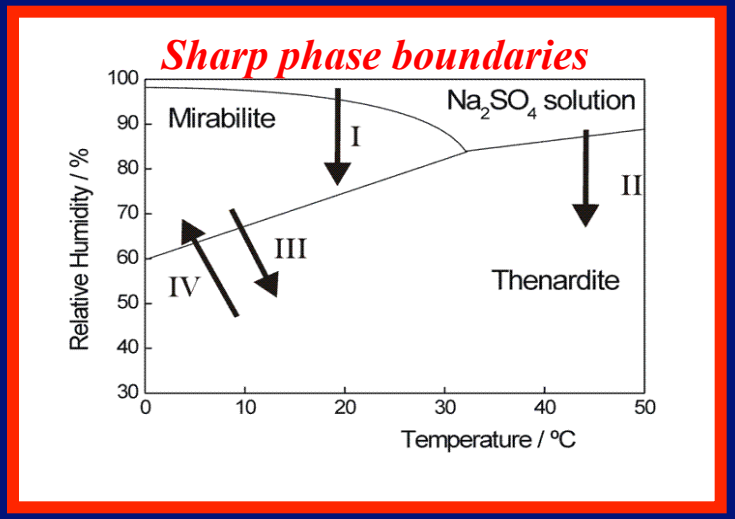
- Salt climatology
- *Colour changes*
- *Propagation of climate indoors: Indoors damage*

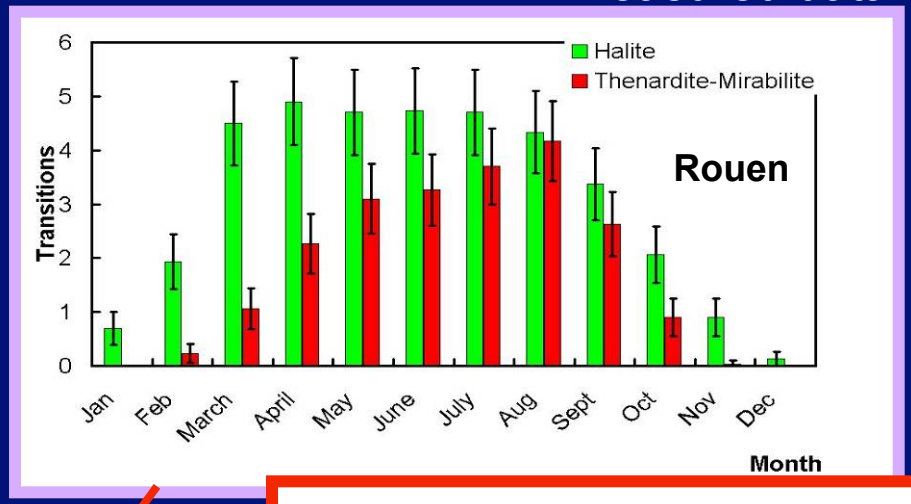
Salt climatology: Seasonality

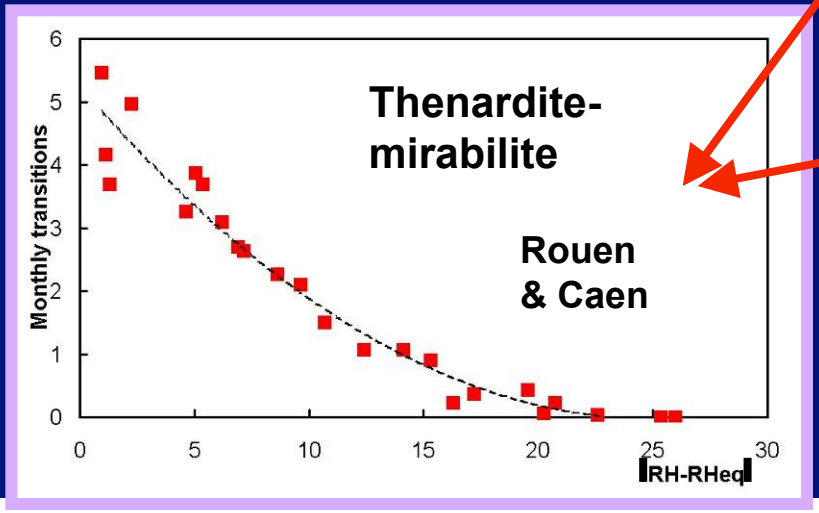
Parameterisation: transitions

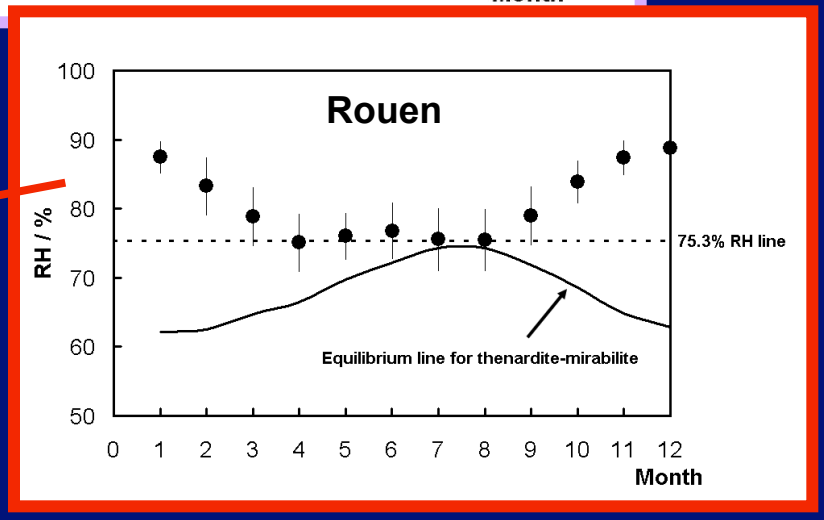
- **Halite (RH = 75.3%)**
- **Thenardite - mirabiite: % RH = 59.11 +0.8759 T**

Measured data 1970-99



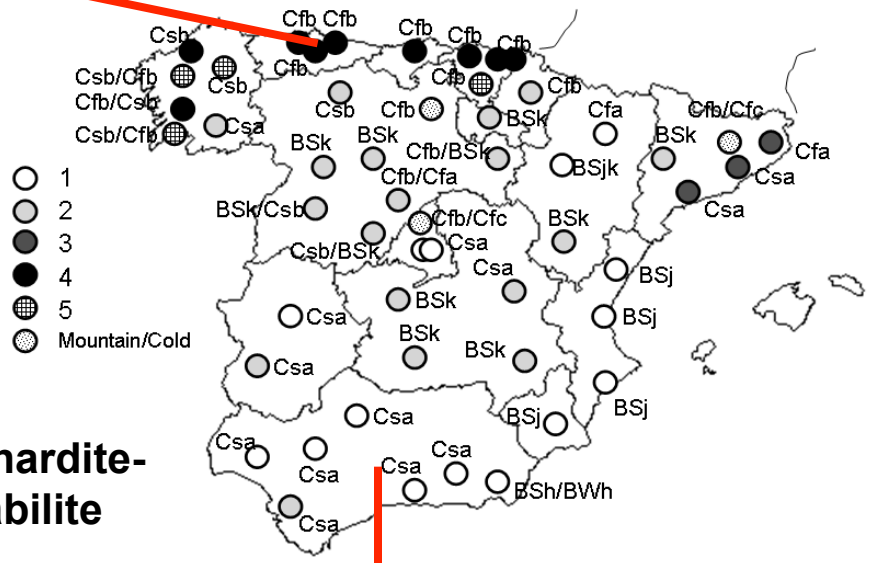


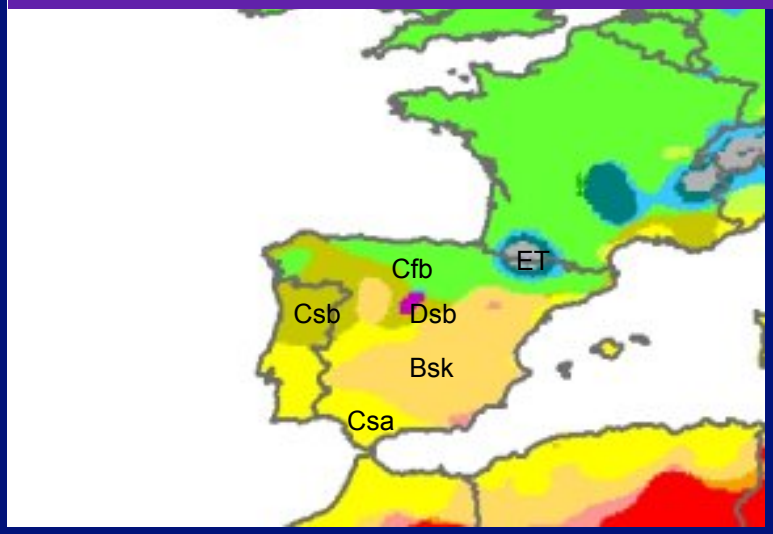




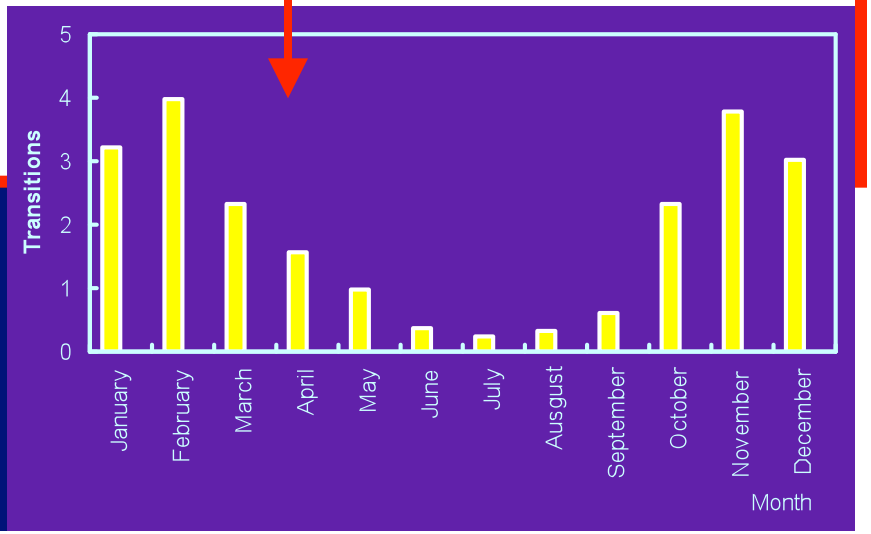
Salt climatology- Peninsular Spain

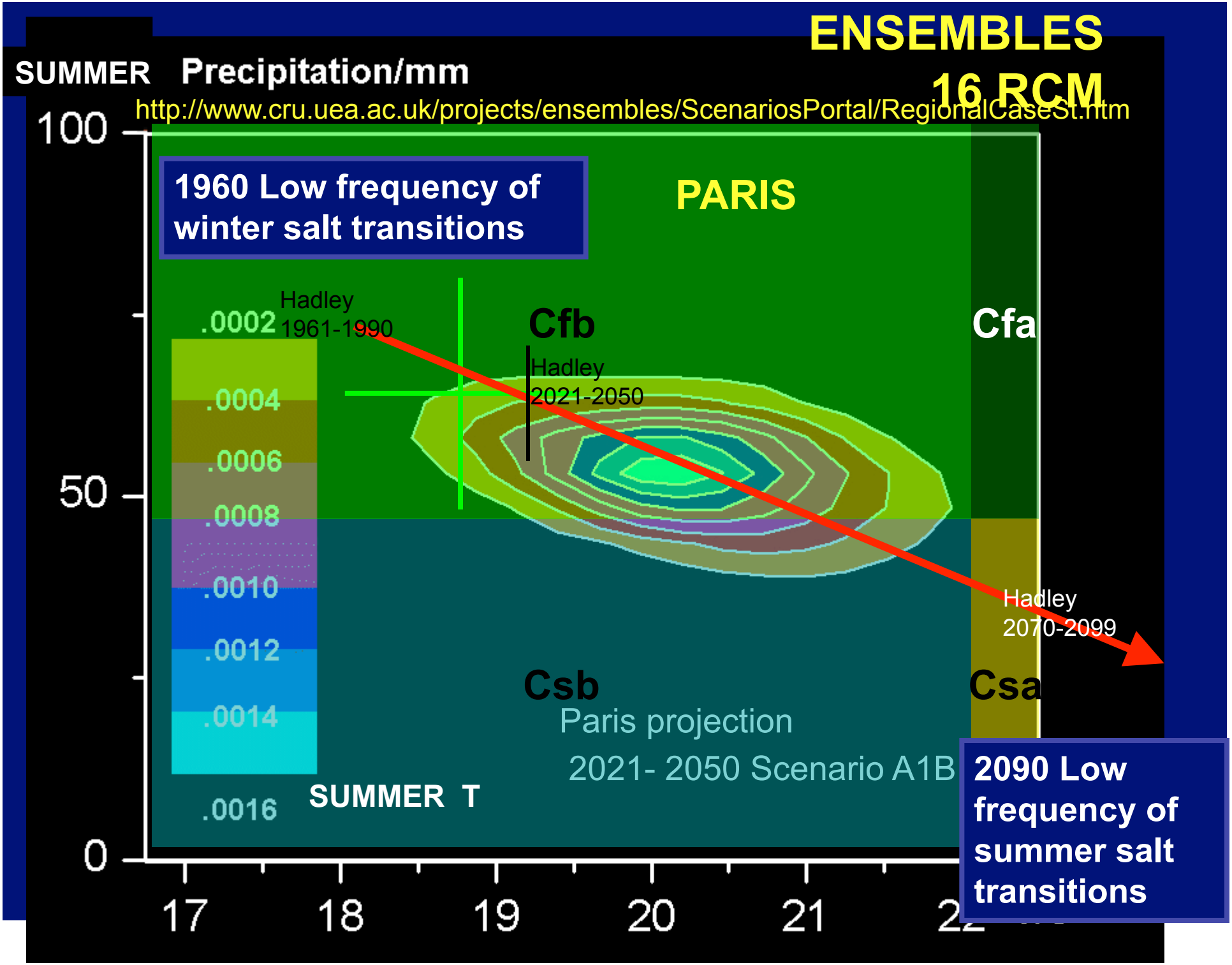
Measured data from 52 stations 1971-2000



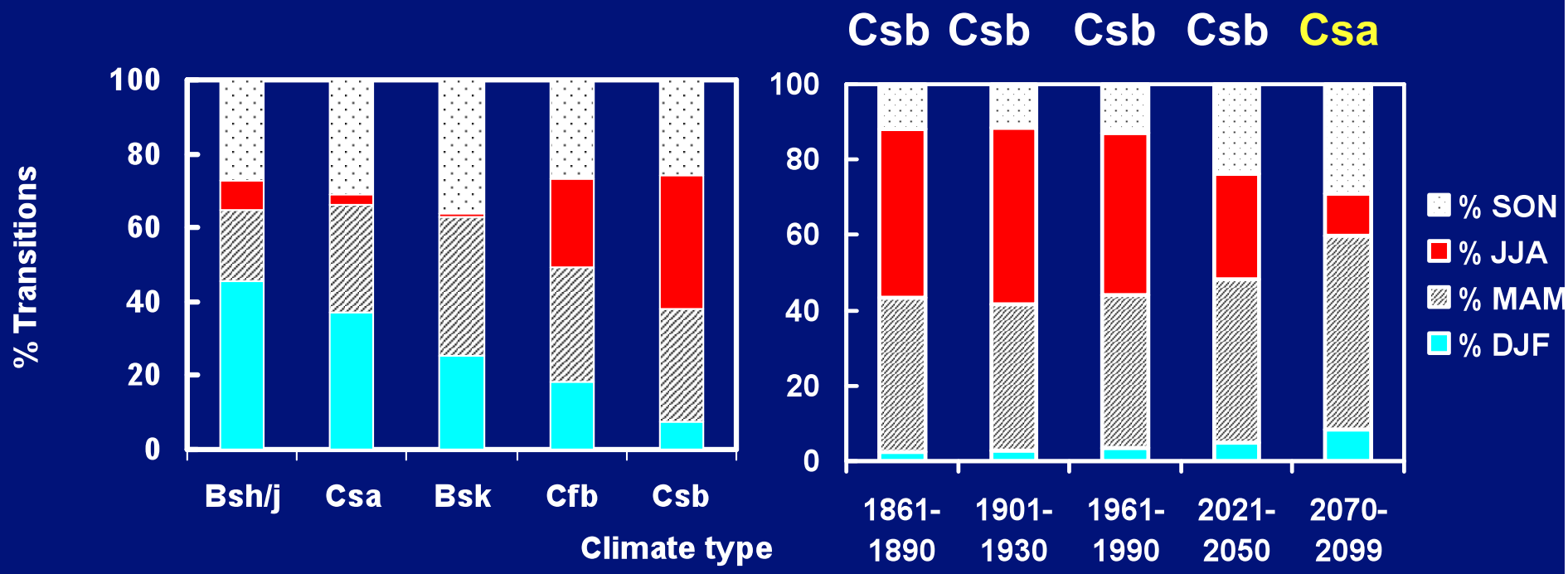


Thenardite-mirabilite




ENSEMBLES
16 RCM
SUMMER Precipitation/mm
http://www.cru.uea.ac.uk/projects/ensembles/ScenariosPortal/RegionalCaseSt.htm
100
50
0
17
18
19
20
21
1960 Low frequency of winter salt transitions
PARIS
Hadley 1961-1990
Hadley 2021-2050
Hadley 2070-2099
Cfb
Cfa
Csb
Csa
.0002
.0004
.0006
.0008
.0010
.0012
.0014
.0016
SUMMER T
Paris projection
2021- 2050 Scenario A1B
2090 Low frequency of summer salt transitions

Salt climatology

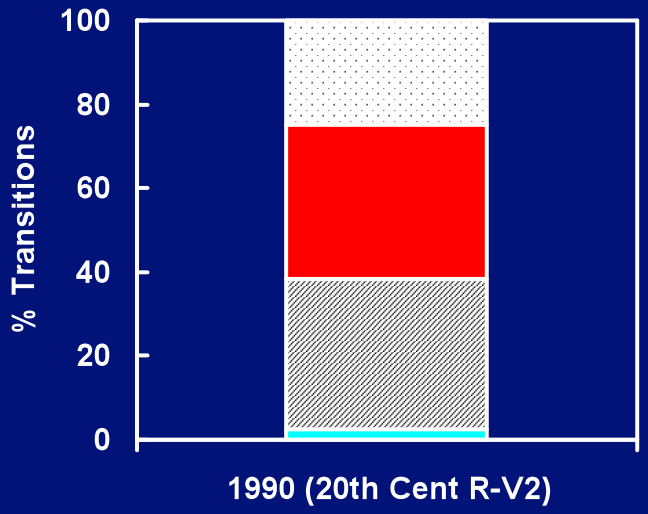


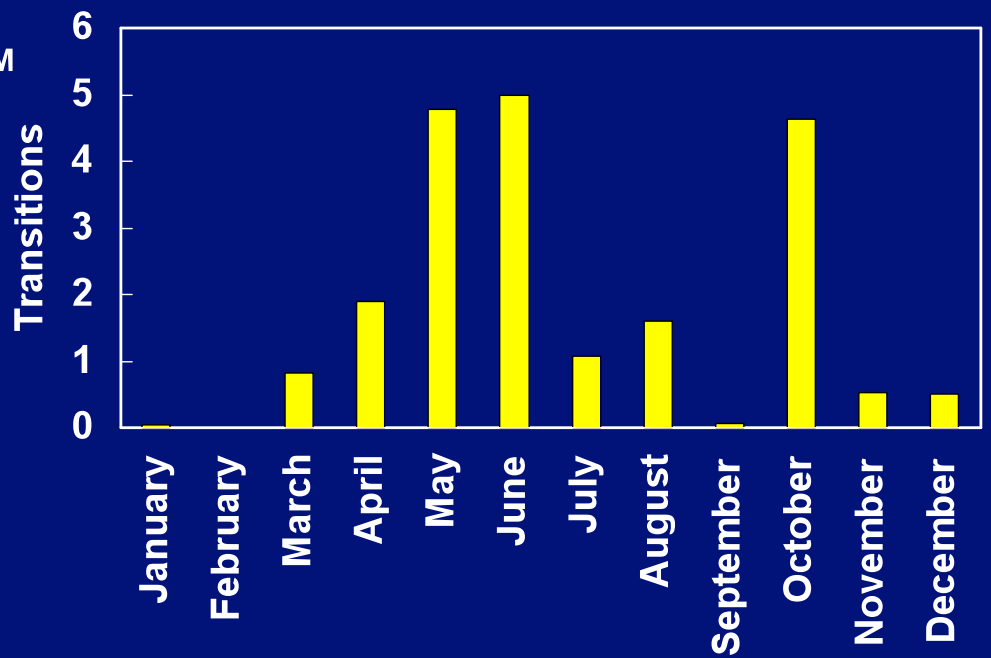
Spain salt climatology

Paris projections (HadCM3a2 “calibrated”)

Salt climatology

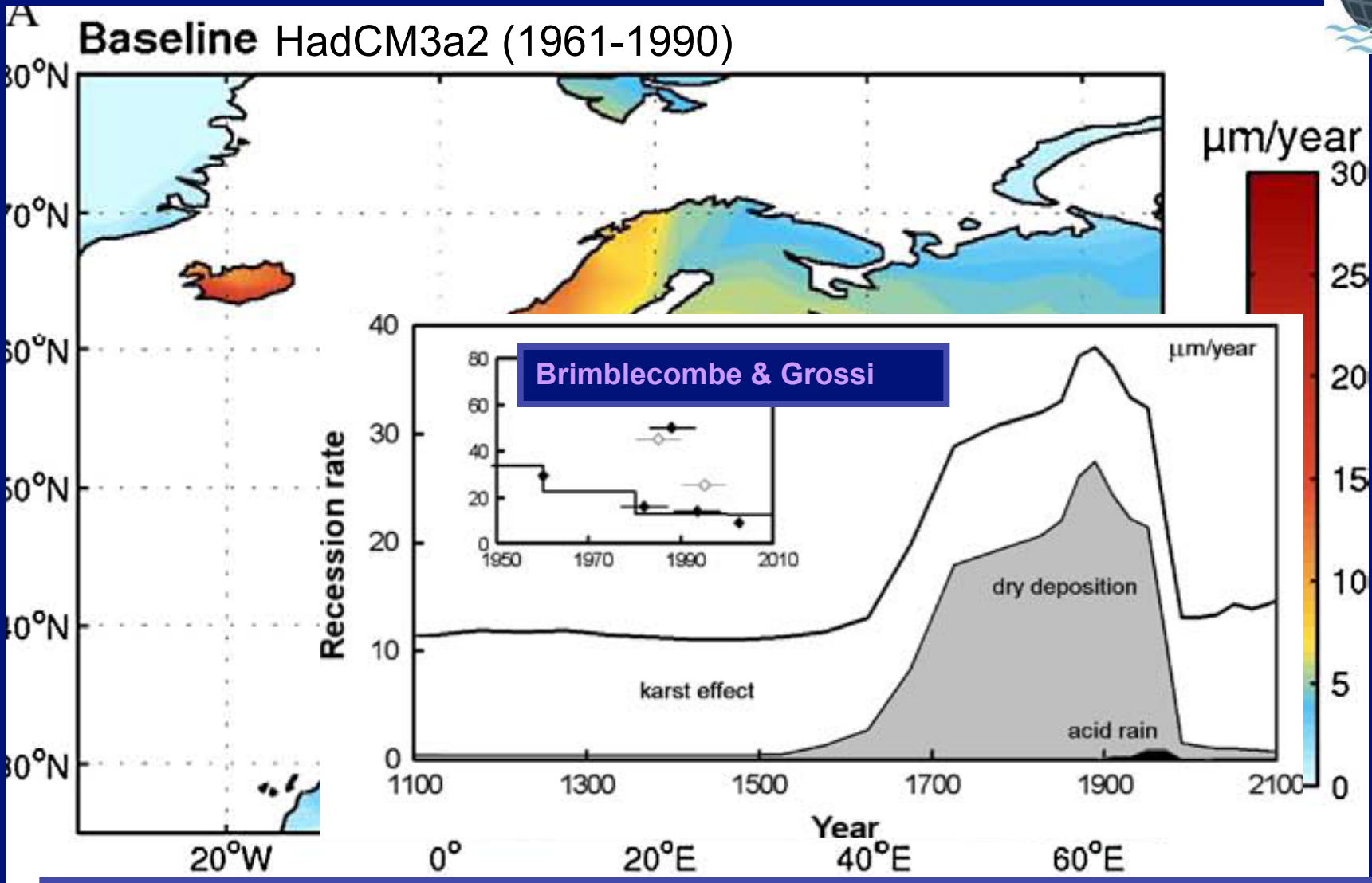
20th Century Reanalysis V2





Air T and RH, Lat 48.4N-48.6N, Long 2.15E – 2.25E, Daily ensemble mean, P levels

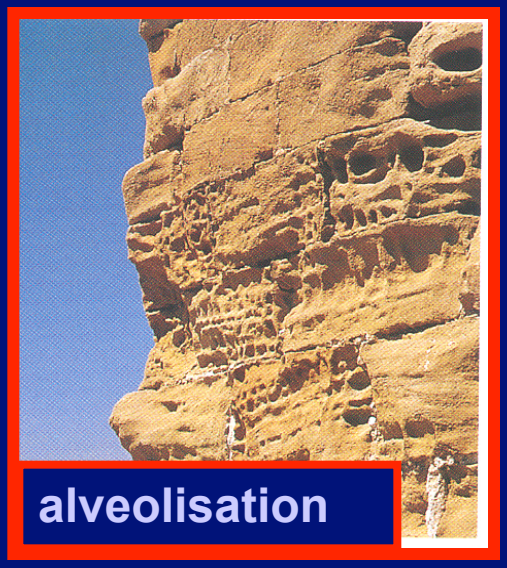
Surface recession: mapping Europe



Bonazza et al, 2009. Mapping the impact of climate change on surface recession of carbonate buildings in Europe . Science of the total Environment

Salt climatology: parameterisation

efflorescence



alveolisation

- The parameterisation focussed in salt transitions, no kinetics or efflorescence
- Limited to mono-salt systems instead of salt mixtures.
- A new heritage parameterisation using documented historic damage would define the predominant damage in different climate areas.

Damage ⇄ Weather (pollution)

Colour of buildings

Desire for cleaning increases with the amount of blackening

REDISTRIBUTION FUNCTIONS: patterns

These may be the most important climatic driven aspects of blackening: strong aesthetic impacts

Data gathering:

- ***Documental***
- ***Photographic***
- ***Surveys: public opinion***

CATHEDRAL OF LEARNING - Pittsburgh

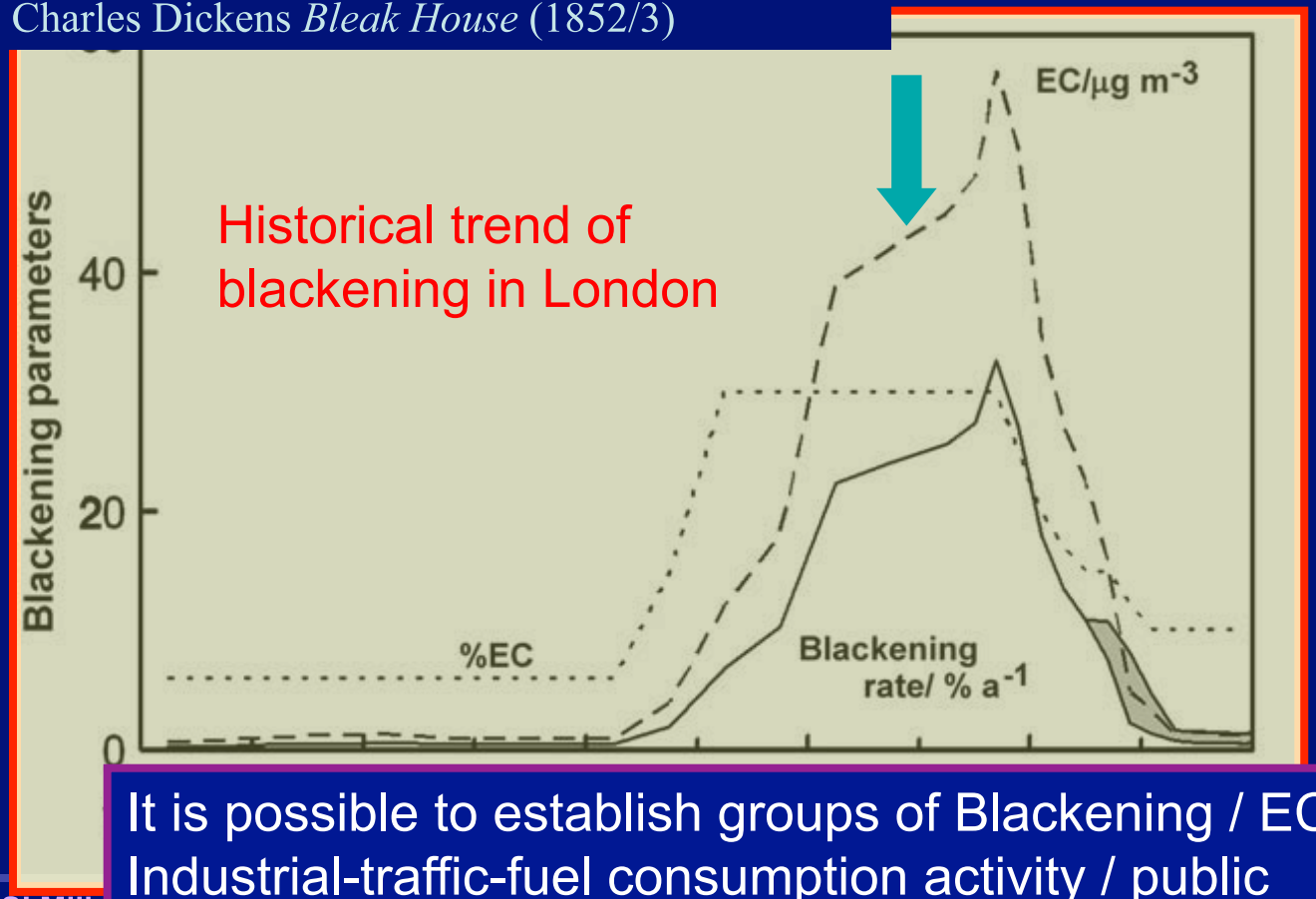
Built in the late 1930's – rapidly soiled, but loss of steel industry meant building became cleaner…

CI Davidson *et al*

Blackening Of London Facades

"For smoke, which is the London ivy, had so wreathed itself round Peffer's…dwelling-place that the affectionate parasite quite overpowered the parent tree."

Charles Dickens *Bleak House* (1852/3)



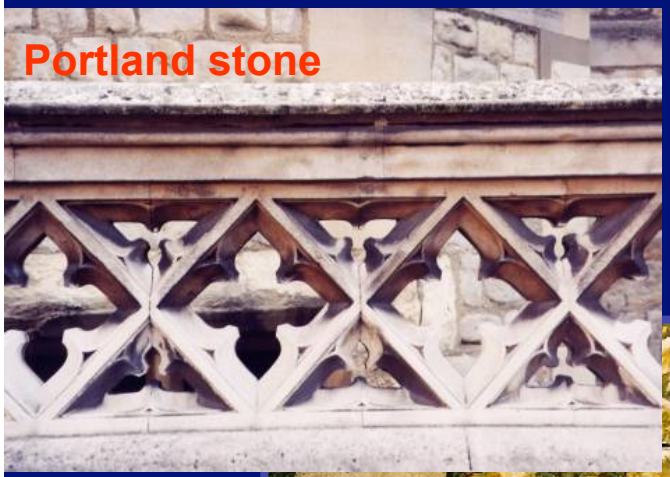
It is possible to establish groups of Blackening / EC / Industrial-traffic-fuel consumption activity / public response

BRIMBLECOMBE & GROSSI Mille
building materials in London, *Sci*
Environment 407, 1354 (2009).

Colour changes: Tower of London

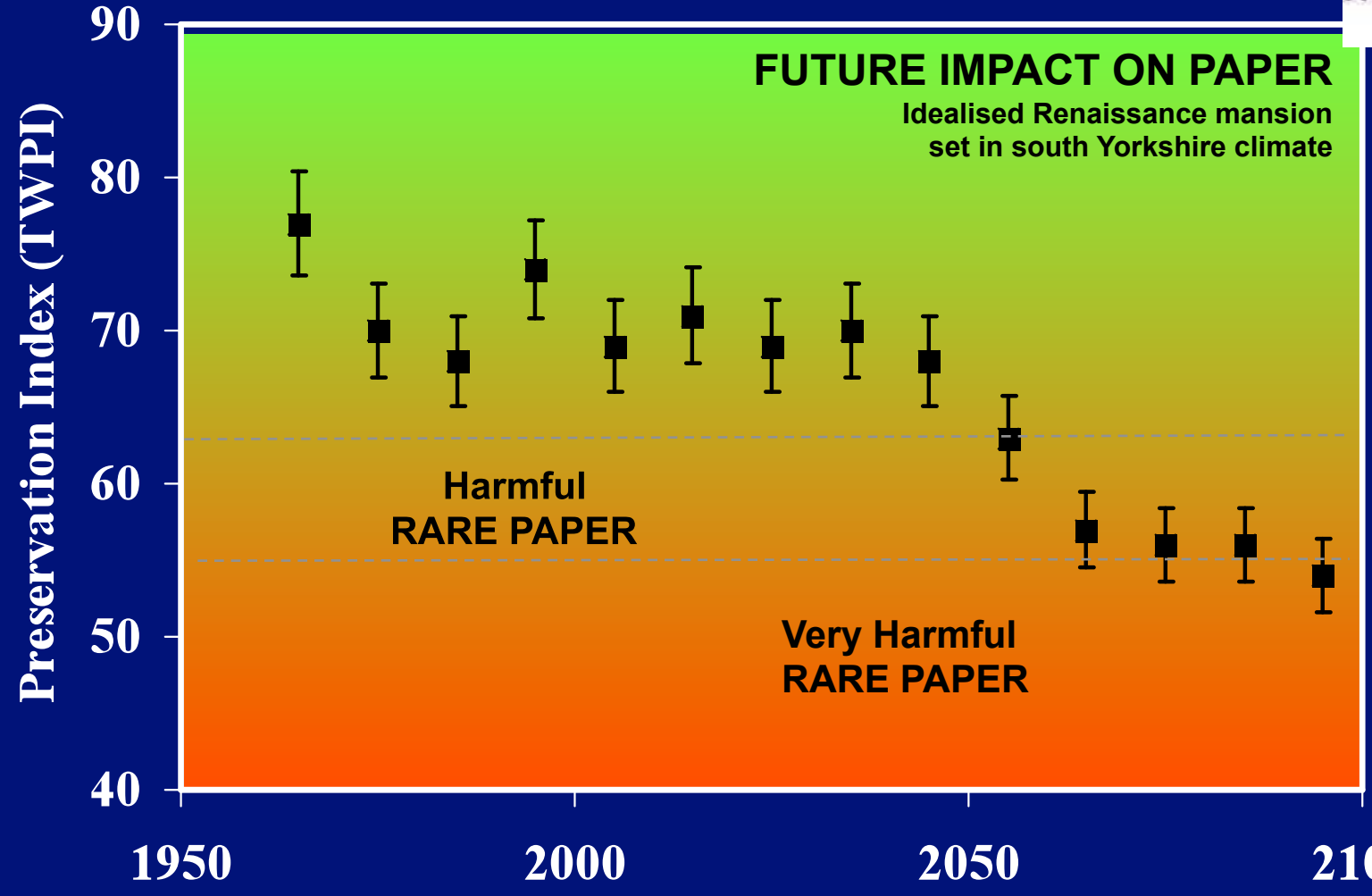
Yellowing at London's *White Tower* oxidation of soot by ozone?

Changing biology – less SO_2 more NO_3^- and warmer conditions



Propagating Climate Change Indoors

Simple indoor/outdoor transfer model for T and RH coupled to downscaled HadCM3a2



Science and Heritage Programme

Decadal accumulations of damage – crude estimate of error from yearly standard deviation

KNOLE

Paul Lankester, UEA