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# Decadal variations in retrieved aerosol optical depth (AOD) from sunshine duration (SD) meausurements over Europe since the late 19$^{th}$ century

$$AOD = f(SD)?$$

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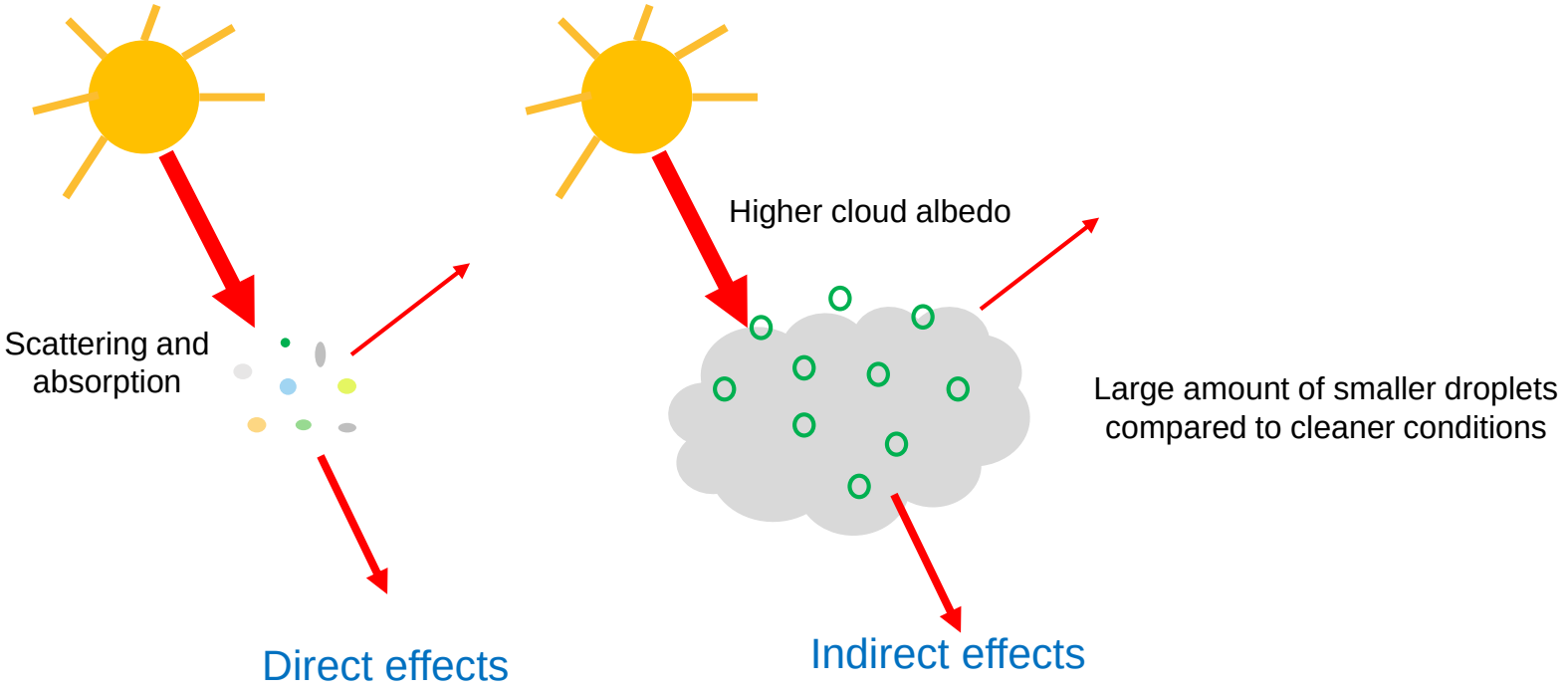
- Why reconstructing the aerosol load in the past?




Aerosol load (AOD) => surface solar radiation => climate change
with variability in *space and time*

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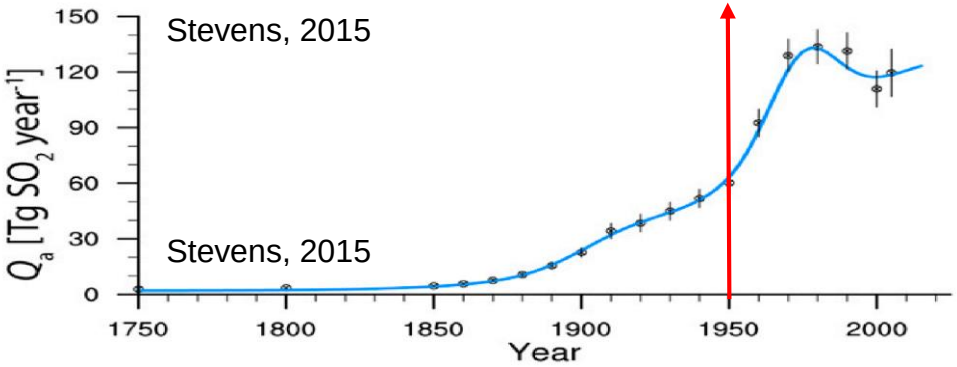
## Why reconstructing the aerosol load in the past?

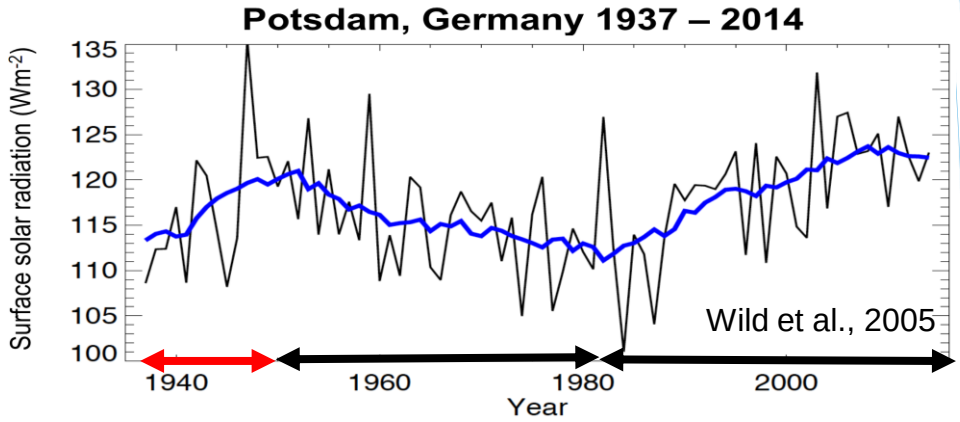
- The present day anthropogenic aerosol forcing ranges between –0.1 W/m2 and –1.9 W/m2, (*IPCC, 2013)*

- Stevens (2015) reduced the uncertainty over the Northern Hemisphere, it ranges between –0.3 W/m2 and –1.0 W/m2

- based solely on SO2 emissions *vs* AOD comprises black carbon and organic aerosols

- constantly increasing of aerosol load before 1980 *vs* opposite findings of decreasing aerosol load before 1950



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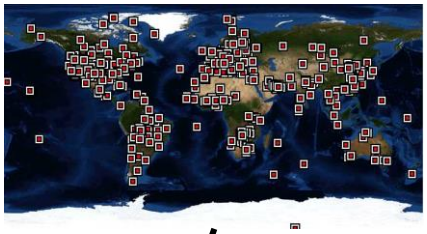
- Why sunshine duration measurements?

Sun photometer

Nimbus satellites
**1978s**

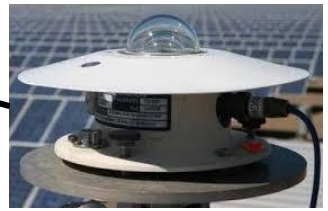
AERONET stations
Cimel sun photometer



No aerosol information available

1955 1960 1965 1970 1975 1980 1985 1990 1995 2000

**Sunshine duration recorder (from 1880 onwards)**



Pyranometer

International Geophysical Year
1957-1958
“solar radiation measurements”

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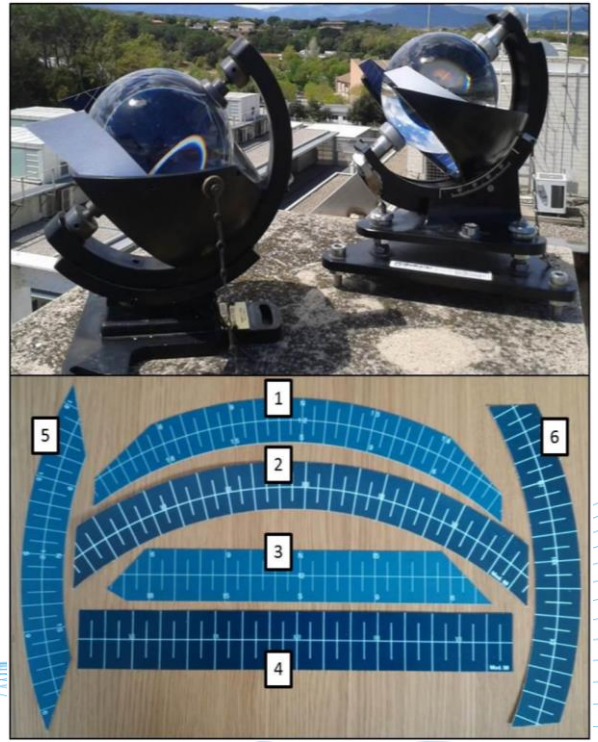
## Why sunshine duration measurements?

- Sunshine duration (SD) for a given period, mostly a day, is defined as the sum of the sub-periods for which broadband direct normal irradiance (DNI) is greater than the threshold value (or *burning threshold*) of 120 W $m^{-2}$ (WMO, 2008)
- A proxy to infer AOD because an increase of AOD => decrease of direct irradiance => decreasing SD value
- One of the longest time series of meteorological measurements since the late $19^{th}$ century and with a noticeable spatial coverage over the world.

CSD recorder

fully automatic but from 2000 onwards

Campbell–Stokes recorder (CSSR)

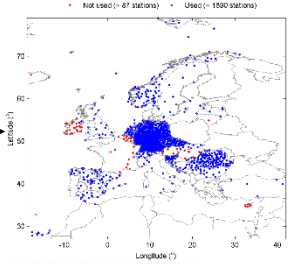



Burn card

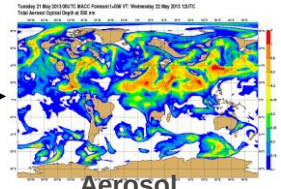
# AOD = f (SD) ?

- Overview of the methodology

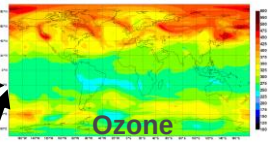
**Sunshine Duration (SD) & Cloud Cover (CC)** from ECA&D database



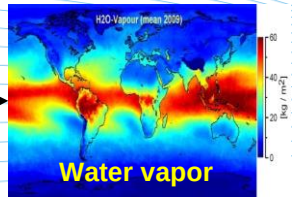

**MERRA-2 reanalysis AOD products** (2000 onwards)




**OMI ozone** (2004 onwards)

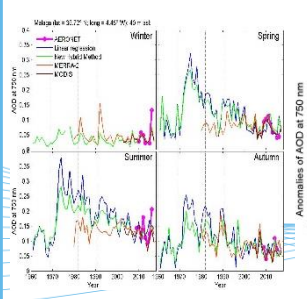


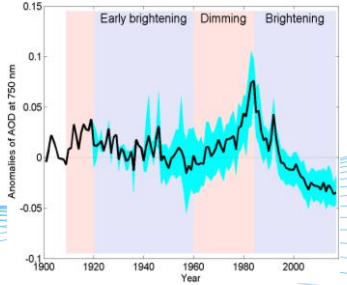

**ECMWF ERA-20C water vapor & ozone** (1900-2010)

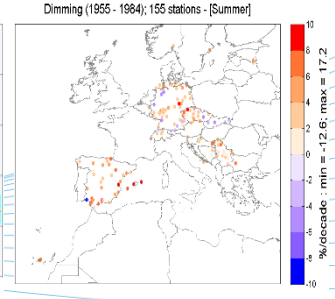



**New Hybrid Method (NHM) (Wandji Nyamsi et al., 2020)**

**Seasonal means, corresponding anomalies trend maps**




Wandji Nyamsi, W.; Lipponen, A.; Sanchez–Lorenzo, A.; Wild, M. and Arola, A. (2020), A hybrid method for reconstructing the historical evolution of aerosol optical depth from sunshine duration measurements, AMT Discussions.

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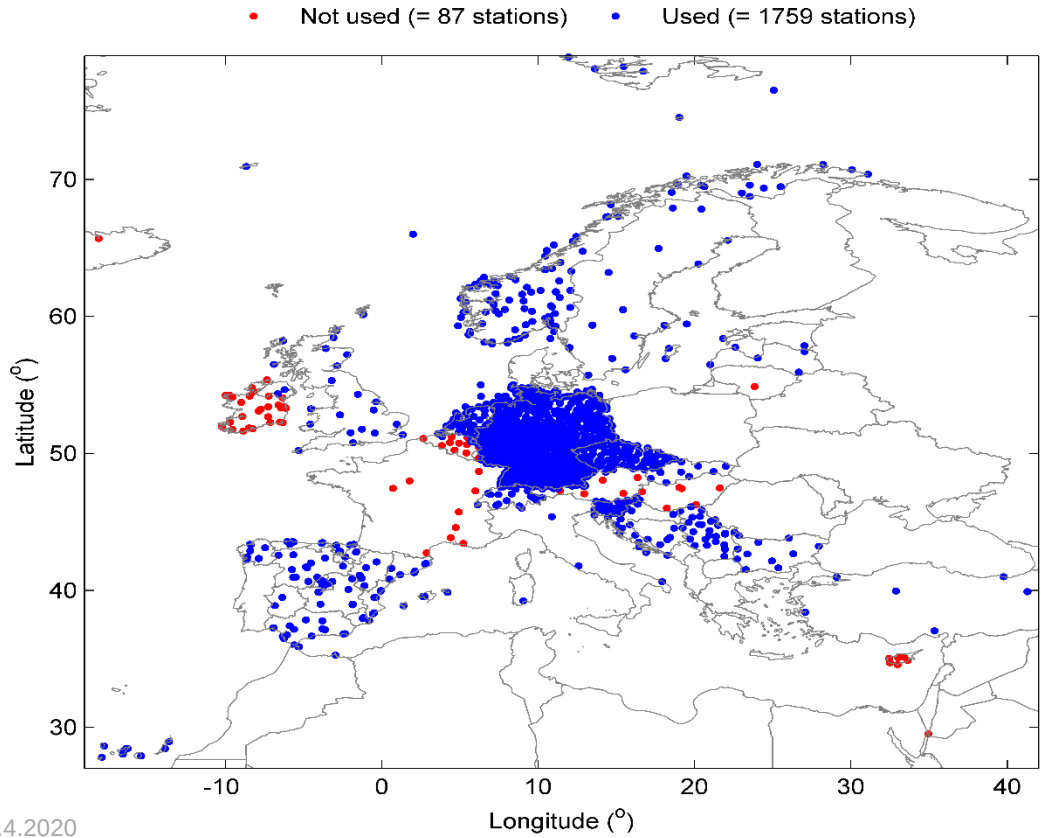
- ECA&D database




- => **ground-based stations having both SD and CC measurements with a maximum distance of 50 km**

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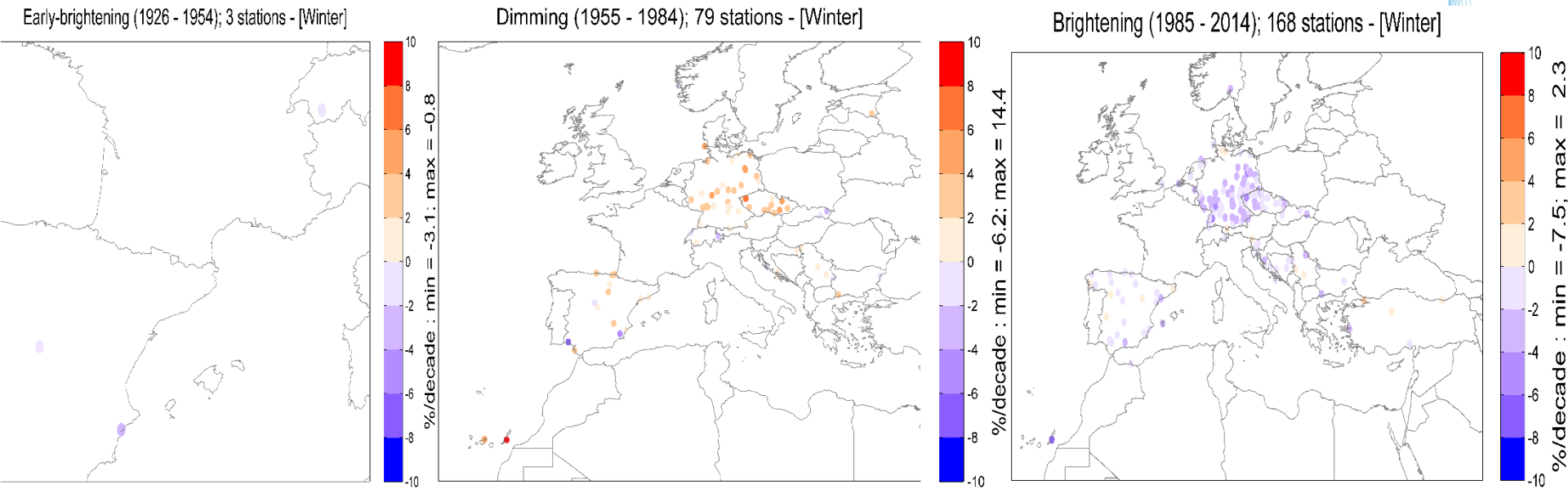
- AOD trend maps: winter season (p-value<=0.05 & #data >=50%)



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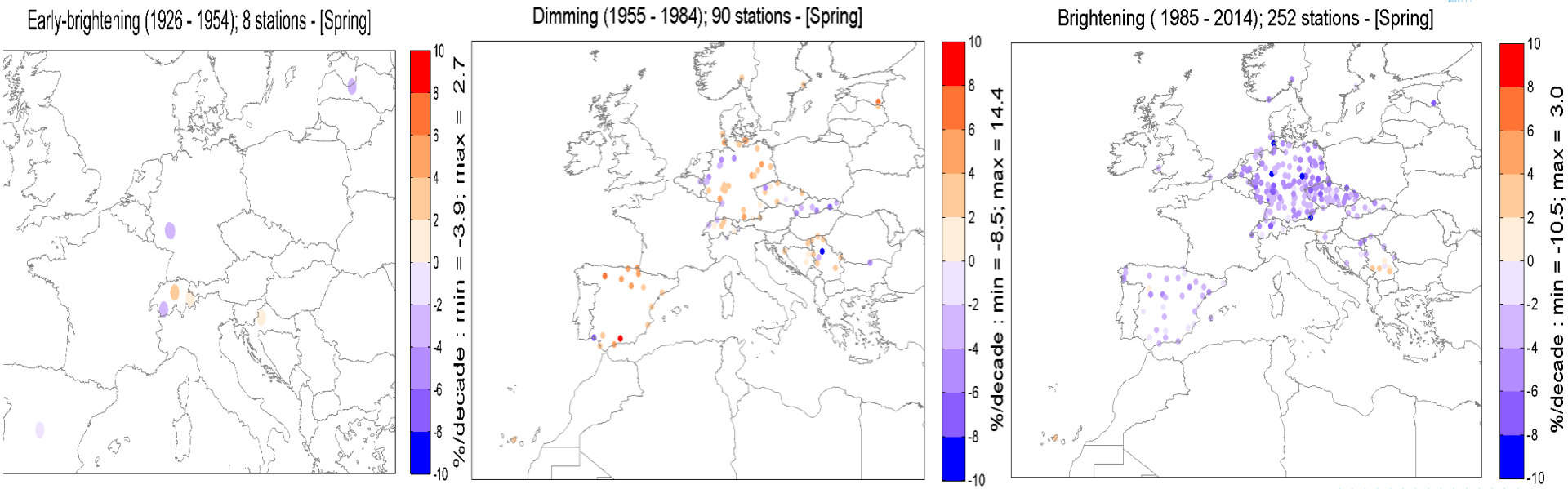
- AOD trend maps: spring season (p-value<=0.05 & #data >=50%)



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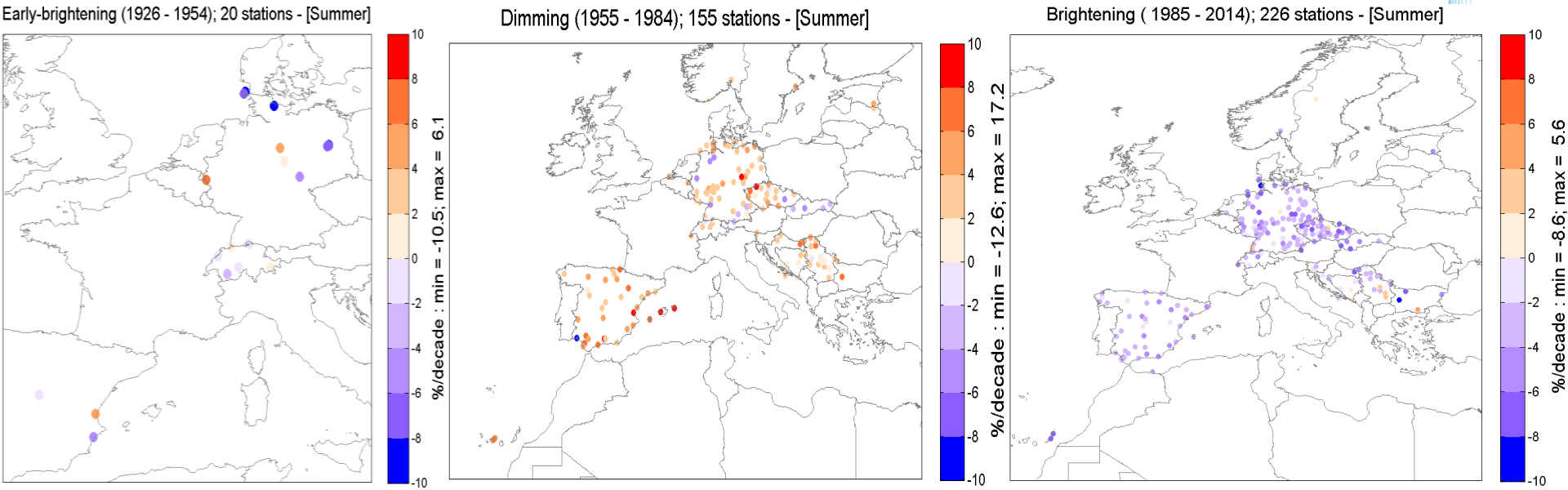
- AOD trend maps: summer season (p-value<=0.05 & #data >=50%)



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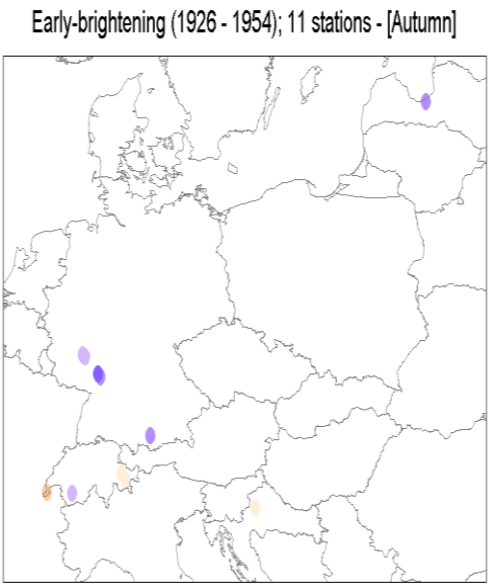
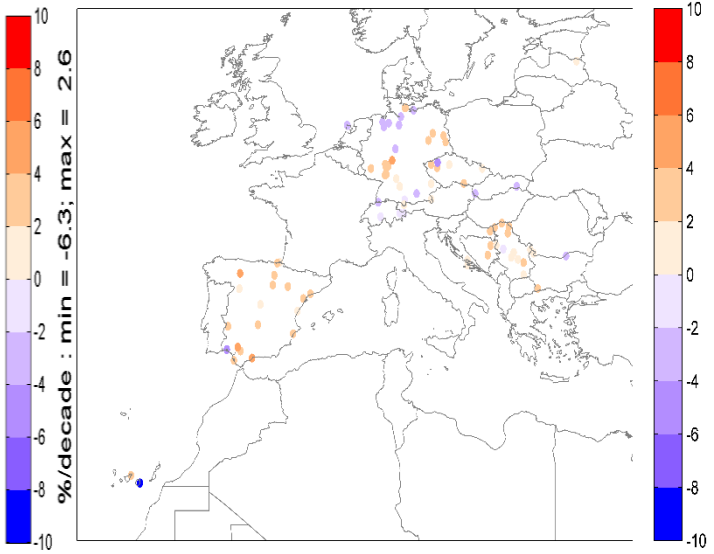
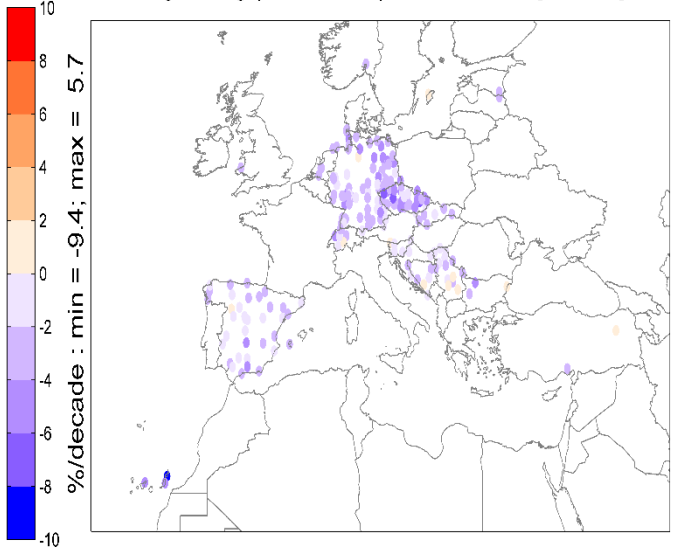
- AOD trend maps: autumn season (p-value<=0.05 & #data >=50%)



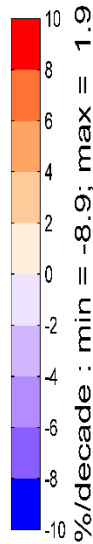












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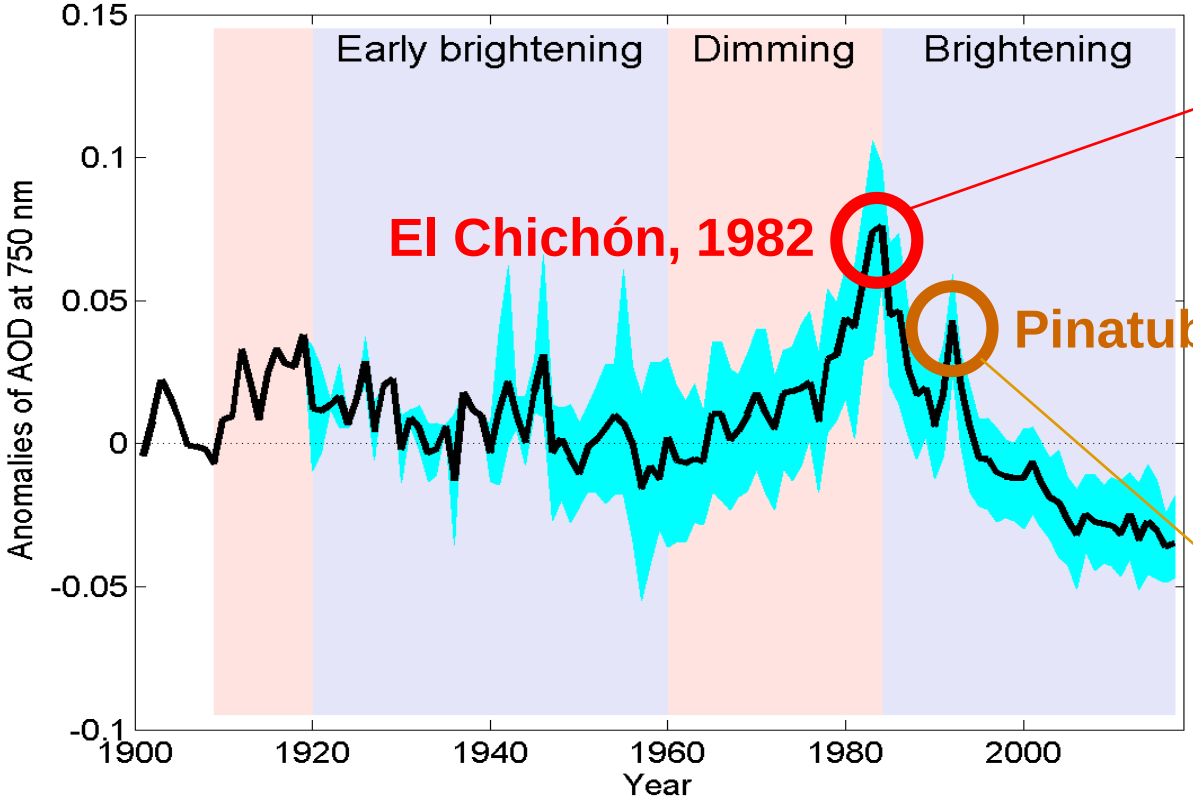
- Long-term annual variations of AOD anomalies since 1900




- Evidence of brightening/dimming phenomenon and volcanic eruptions

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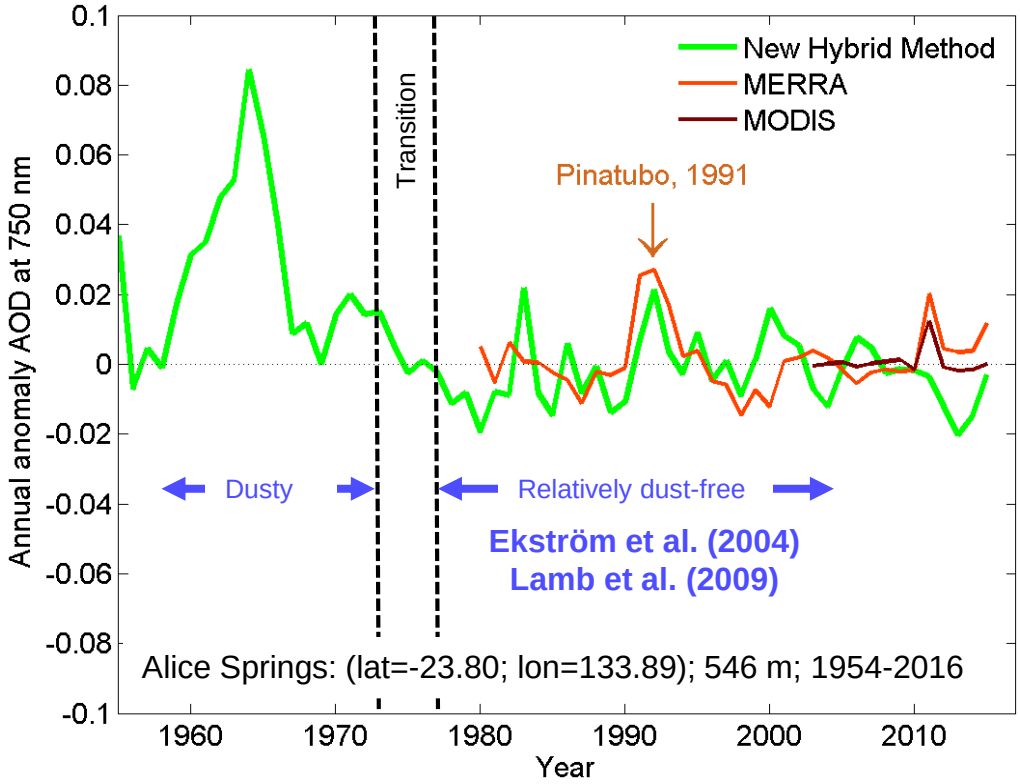
- **A bonus** : annual AOD anomalies for Alice Springs (Australia)




**Lake Eyre (major dust source region)**




Thanks to Bruce Forgan for providing SD and CC measurements over Australia

# AOD = f (SD) ?



## Conclusions and *perspectives*

- The new hybrid method for reconstructing the past AOD from SD measurements is applied
- Compatible with volcanic eruptions, early brightening, dimming and brightening phenomenon over time. Preliminary evidence of early-dimming at couples of stations.
- Opposite trends between Eastern and Western EU countries depending on the time period
- *Further investigations should be done to explain discrepancies on the AOD time series*
- *Extension of the study as many sites as possible in other regions of the world such as Africa, America (North & South), Australia and Asia.*

***PLEASE, WE NEED DATA and WE OFFER A CO-AUTHORSHIP (contact me to william.wandji@fmi.fi)***

- *Comparing results with other findings from the literature*

# Thanks…