

Analysis of diurnal cycle of anthropogenic aerosol impacts on clouds using SEVIRI data

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Piia Post

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Outline

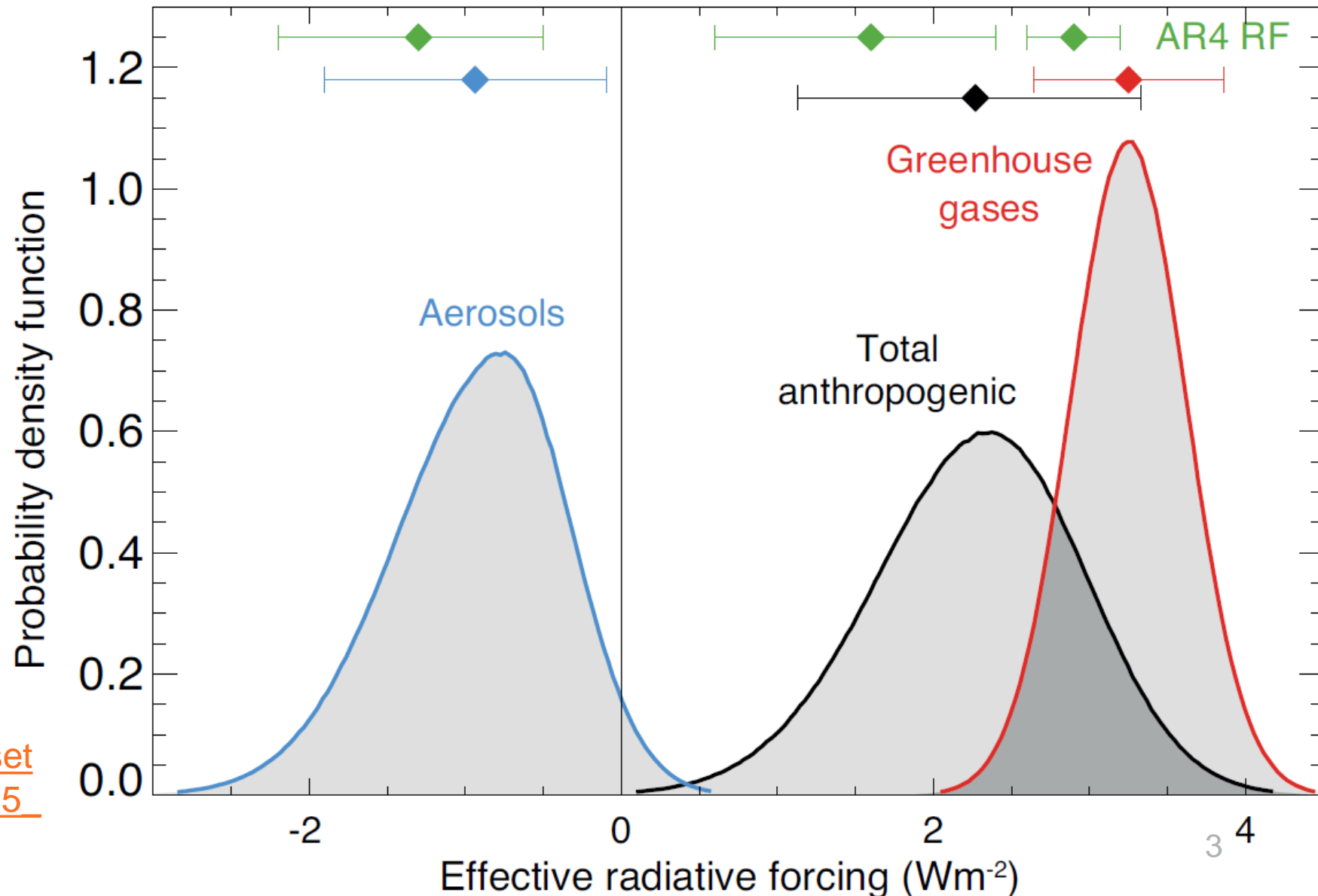
- Motivation and theoretical introduction
- SEVIRI and MODIS data
- Methods
- Results
- Conclusion

Motivation

Majority of the uncertainty in the total anthropogenic radiative forcing comes from the unknown effect of aerosols to clouds

Image: IPCC AR5

https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf



Motivation

- Twomey's hypothesis:
 - Increases in the number of aerosol particles will lead to increases in the concentration of cloud droplets
 - Greater cloud droplet concentration implies larger total surface area which reflects more solar radiation
- Albrecht's hypothesis:
 - A greater concentration of smaller drops (Twomey) suppresses precipitation because the coalescence efficiency of cloud droplets increases strongly with droplet size

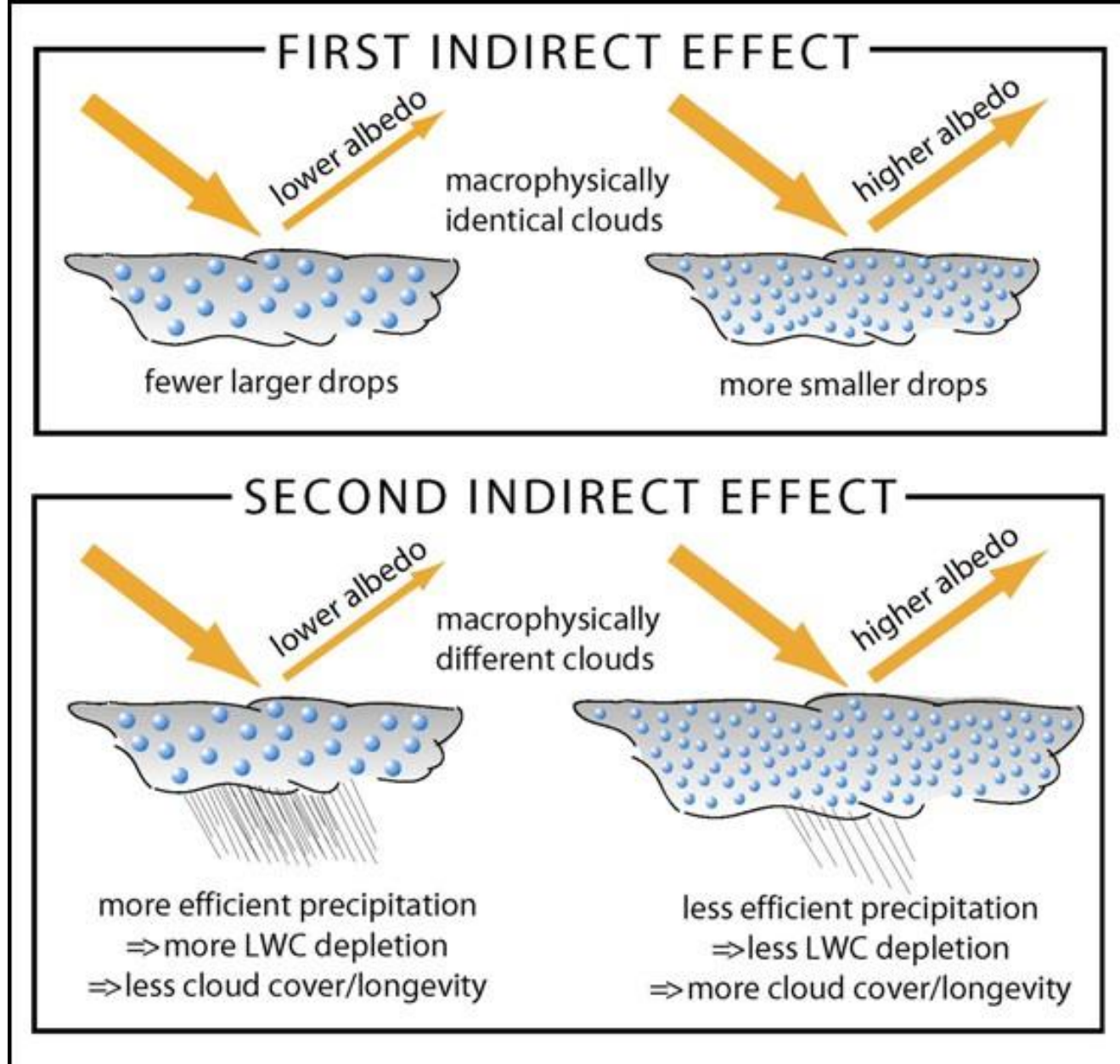
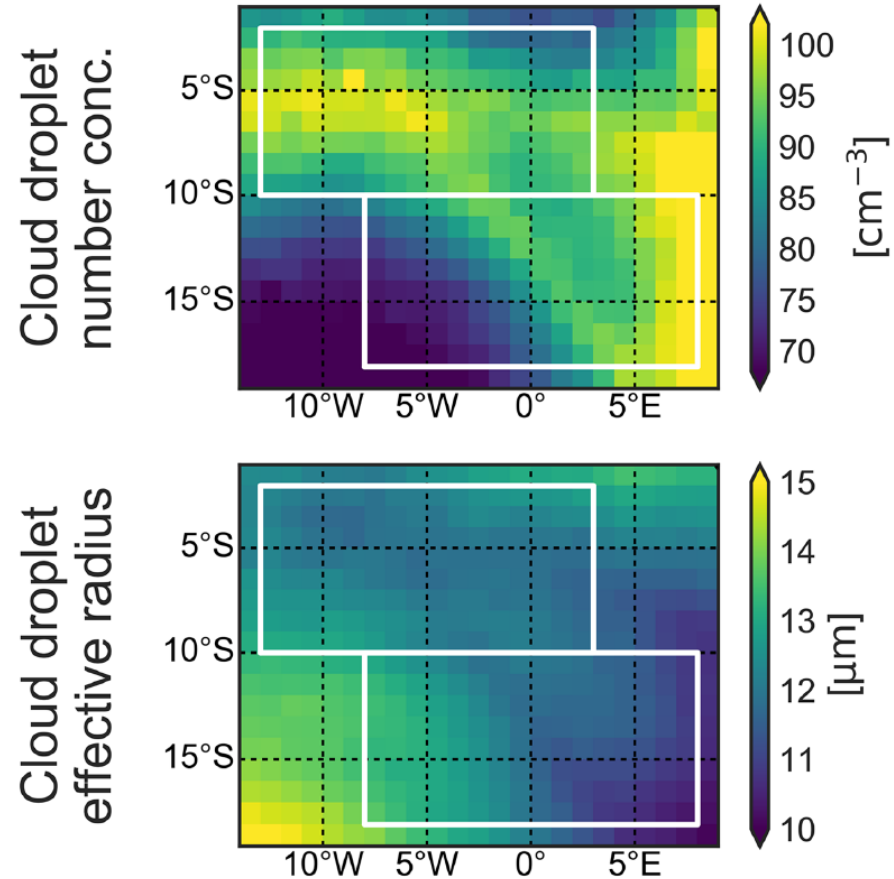


Image: Presentation by Robert Wood, University of Washington
https://atmos.uw.edu/~robwood/PRESENTATIONS/160127_Wood_1ndirectEffect_CCNBudget_ASR.pdf

Motivation – ship pollution tracks

Long time average values
(Data from years 2003-2015):



One single day satellite image
March 4th 2009:

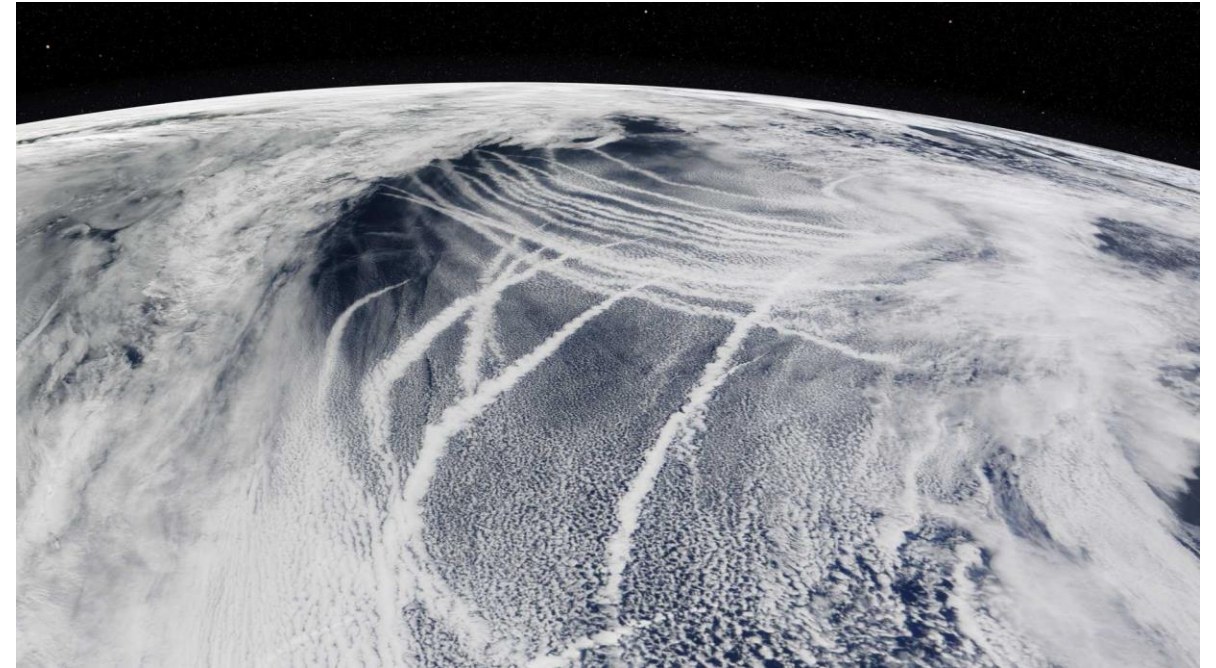


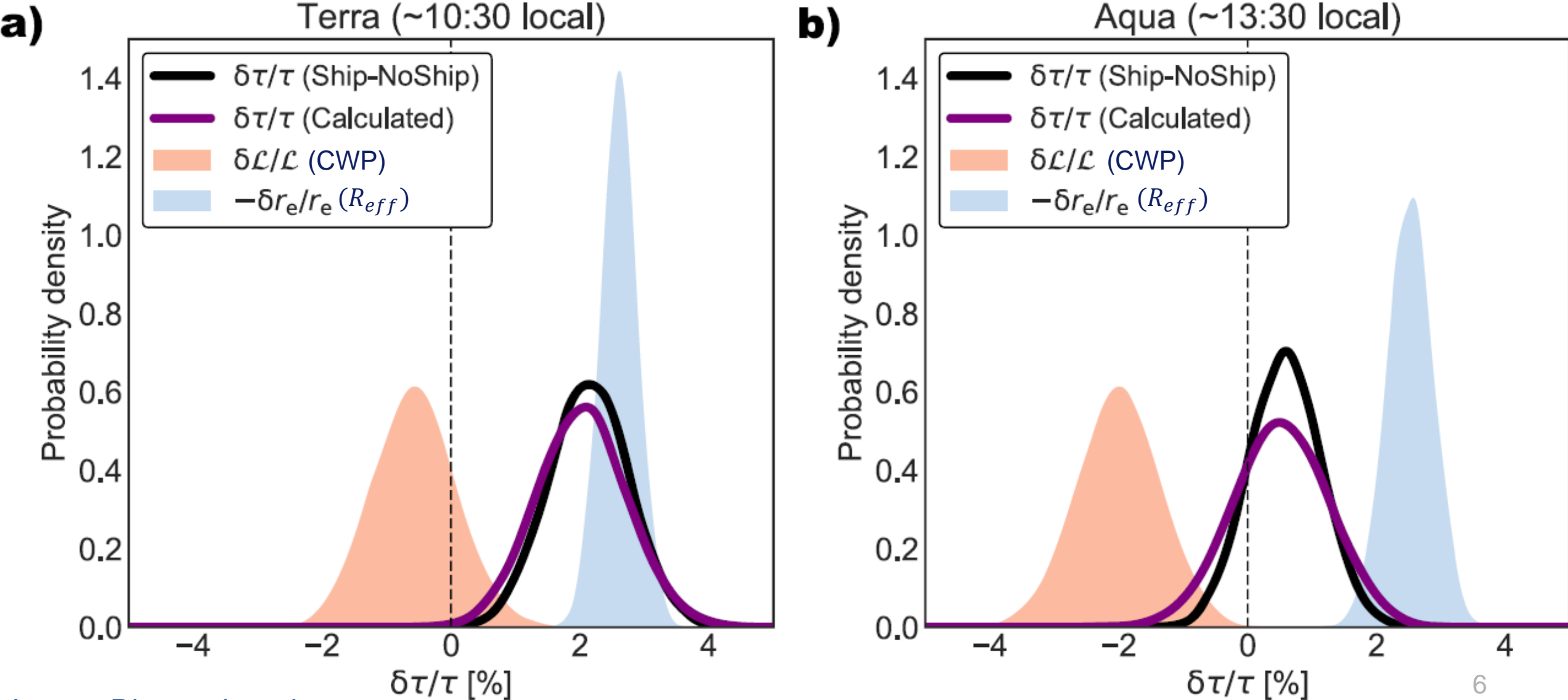
Image: NASA

<https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=3667>

Image: Diamond *et al.*

<https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2019AV000111>

Motivation – diurnal cycle in ship tracks?



SEVIRI and MODIS data

Spinning Enhanced Visible and Infrared Imager - SEVIRI

Moderate-resolution Imaging Spectroradiometer – MODIS

- The Cloud Physical Properties (CPP) algorithm developed by KNMI is used
- Study area is focused around Western part of Russia
- In total 23 cases were used (cases from 2006 – 2017)

SEVIRI and MODIS data

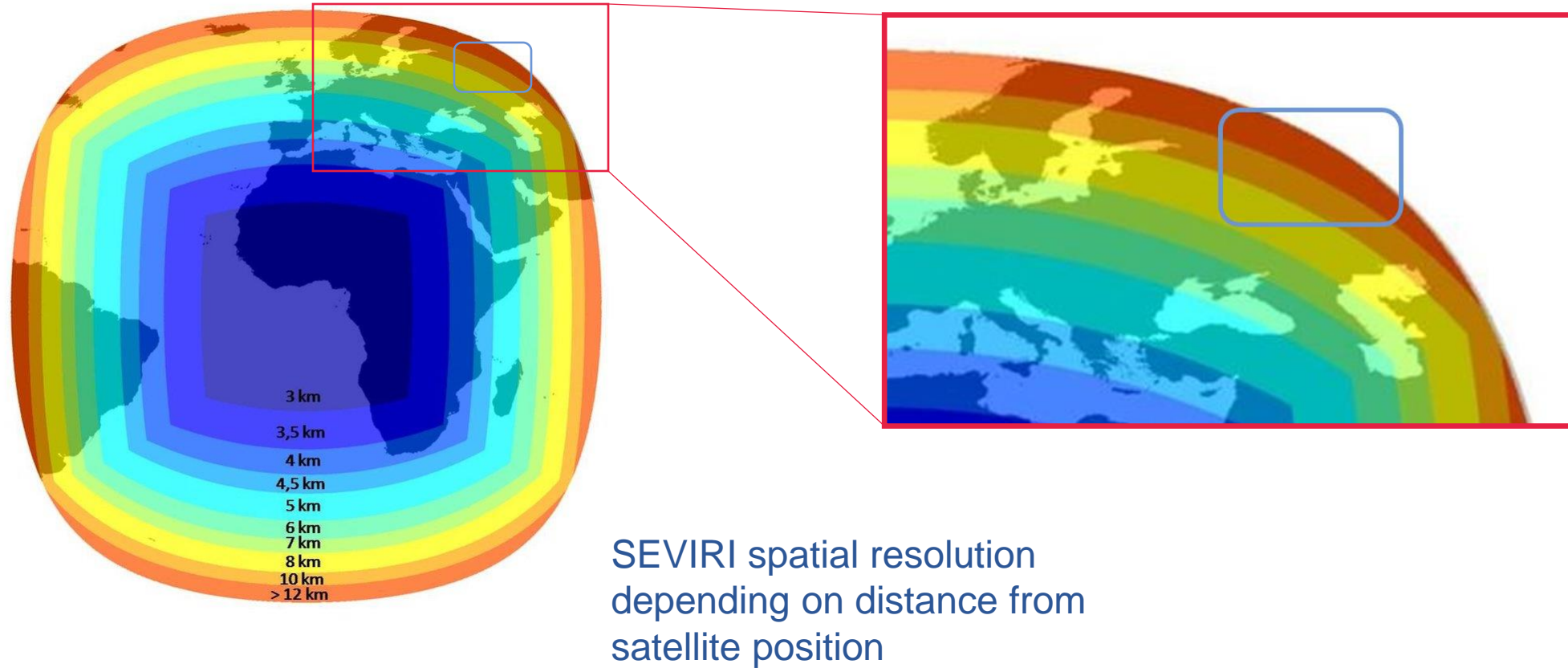
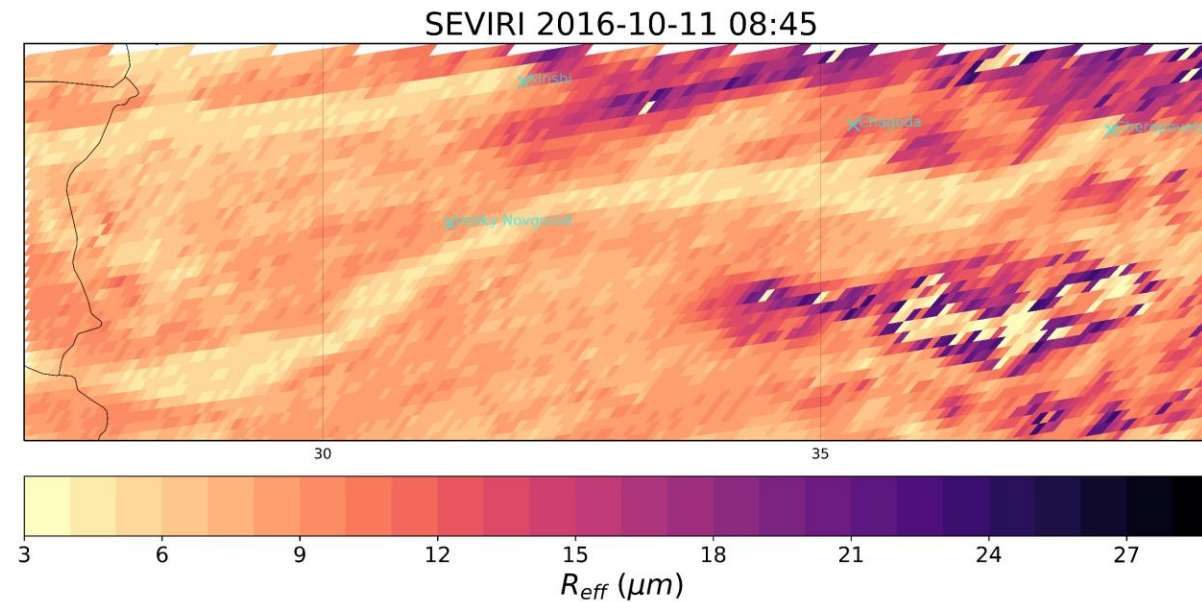


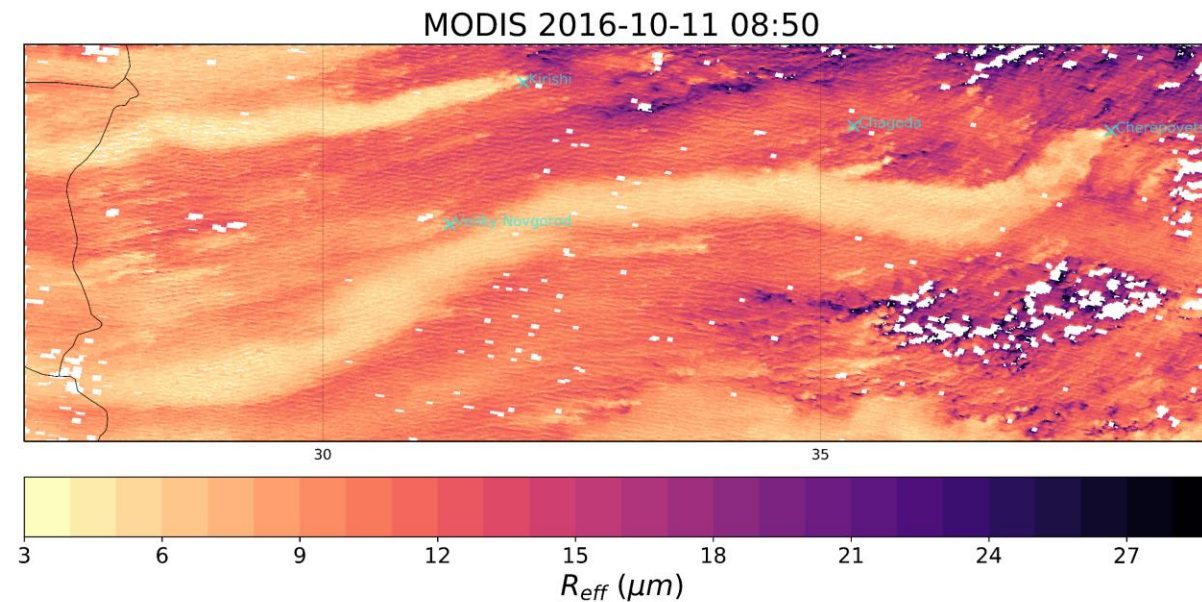
Image: Korany *et al.*

https://www.researchgate.net/publication/305320406_A_database_of_multi-year_2004-2010_quality-assured_surface_solar_hourly_irradiation_measurements_for_the_Egyptian_territory

SEVIRI and MODIS data spatial resolution difference



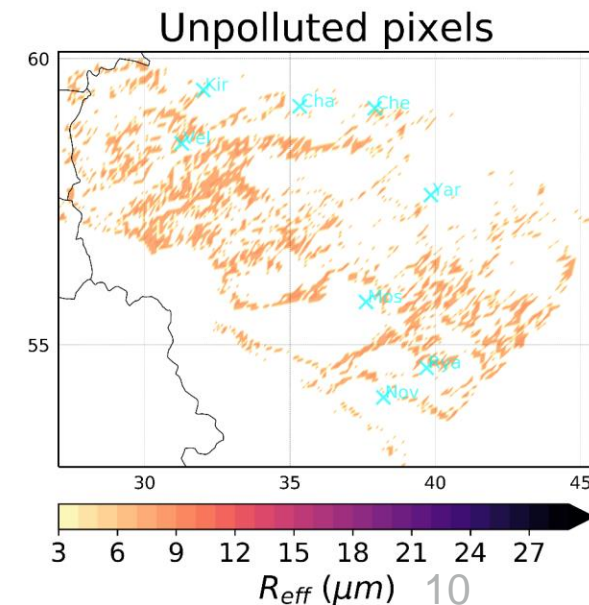
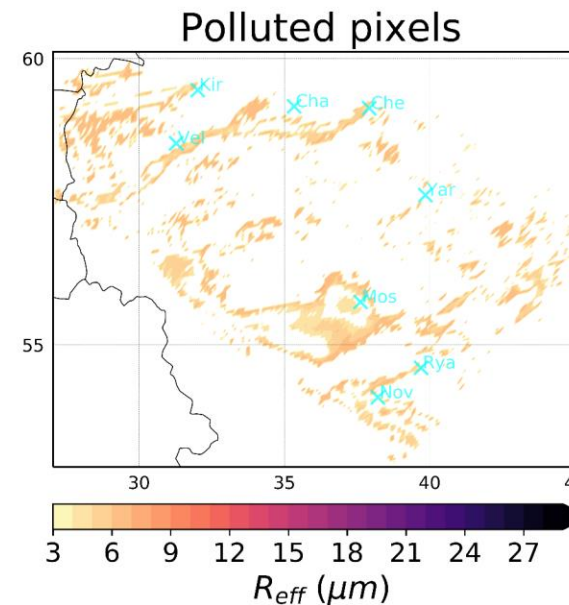
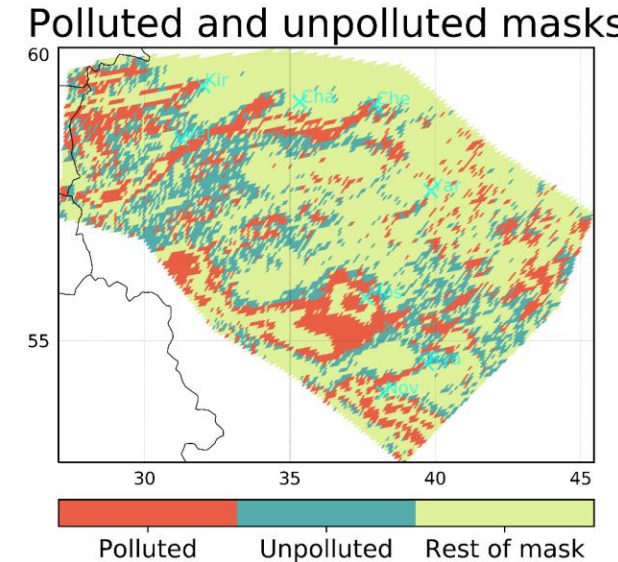
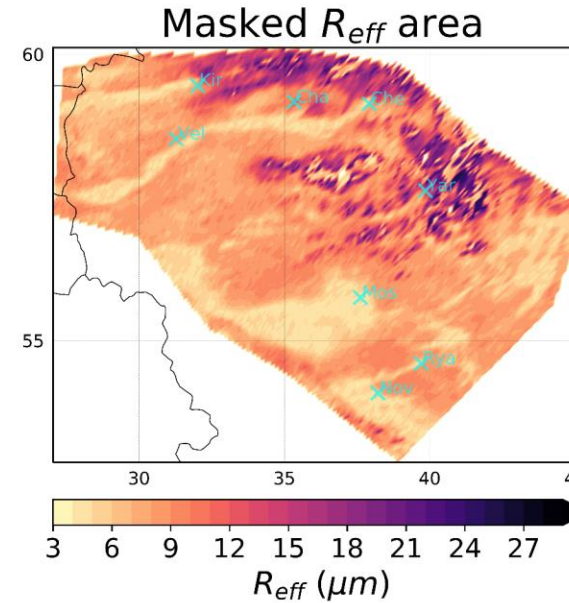
SEVIRI spatial resolution ~10 km



MODIS spatial resolution ~1 km

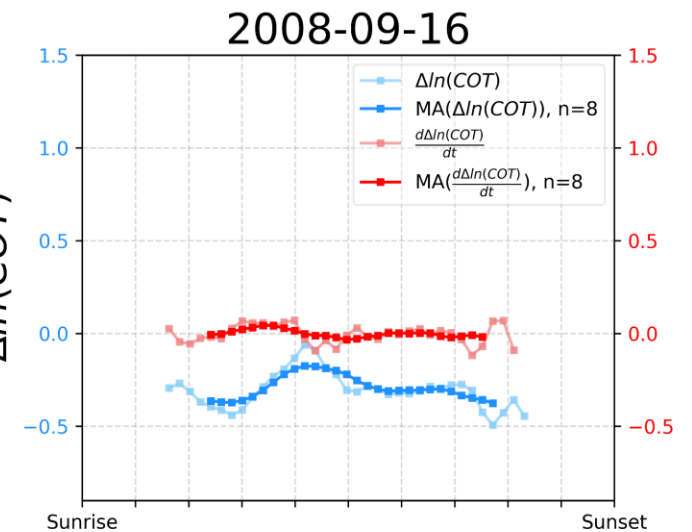
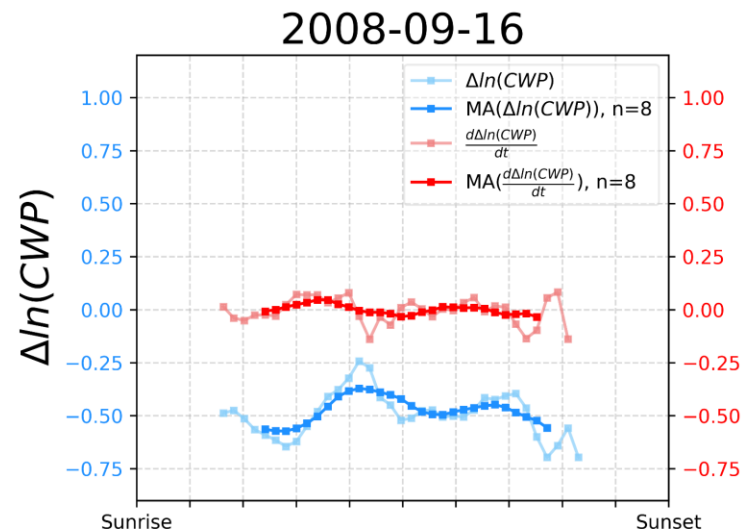
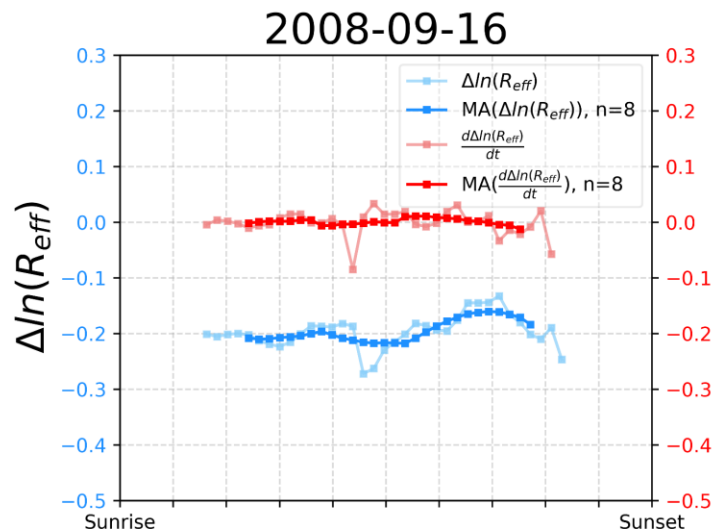
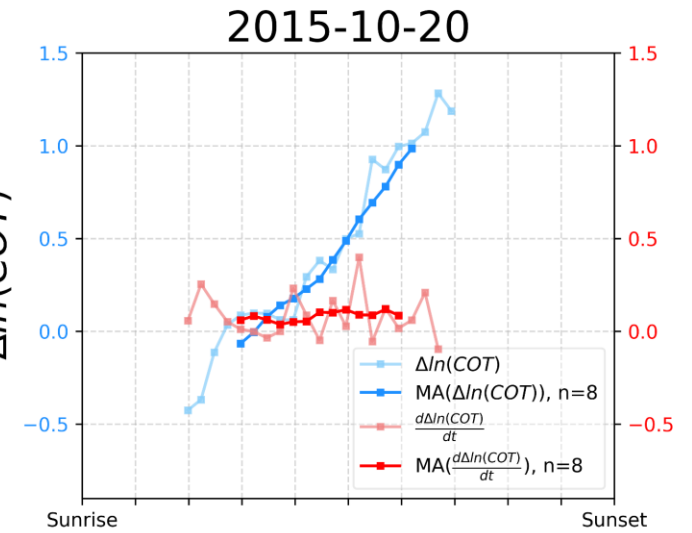
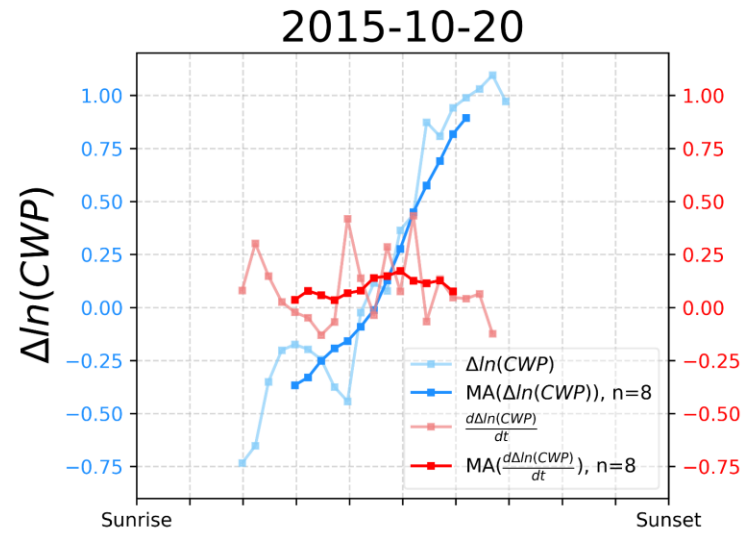
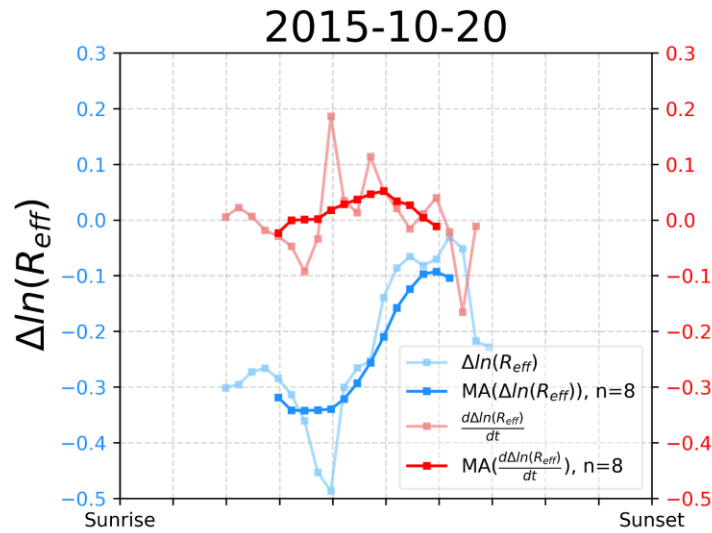
Methods

- Initial visual detection
- Manual area selection
- Data filtering with additional variables and conditions (i.e. liquid water only)
- Data separation to **polluted** (lower 25th percentile) and **unpolluted** (30th – 50th percentile) pixels using cloud droplet size (R_{eff})



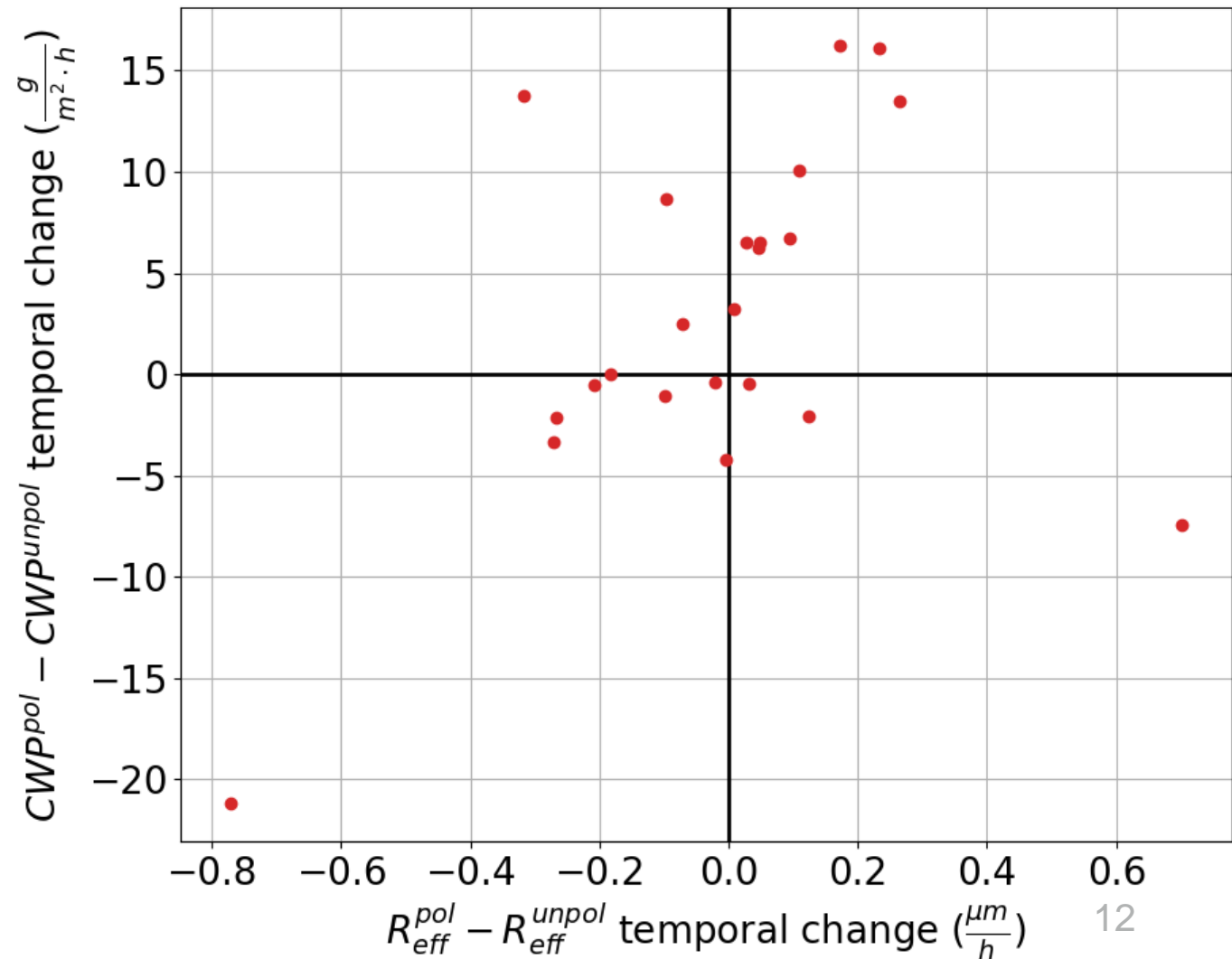
Example of two cases

(MA – moving_average(window=n))



Results

- Average hourly change in linear regression slopes of $\Delta(CWP)$ vs $\Delta(R_{eff})$ data within the 23 cases

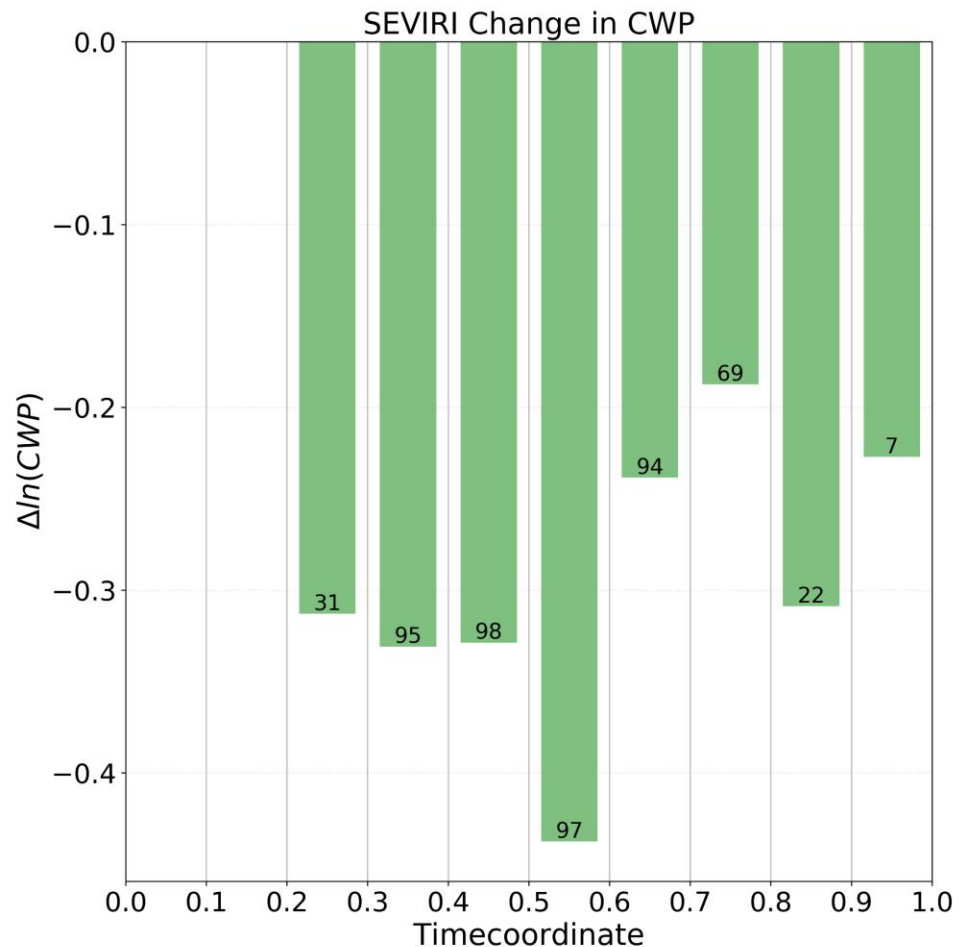
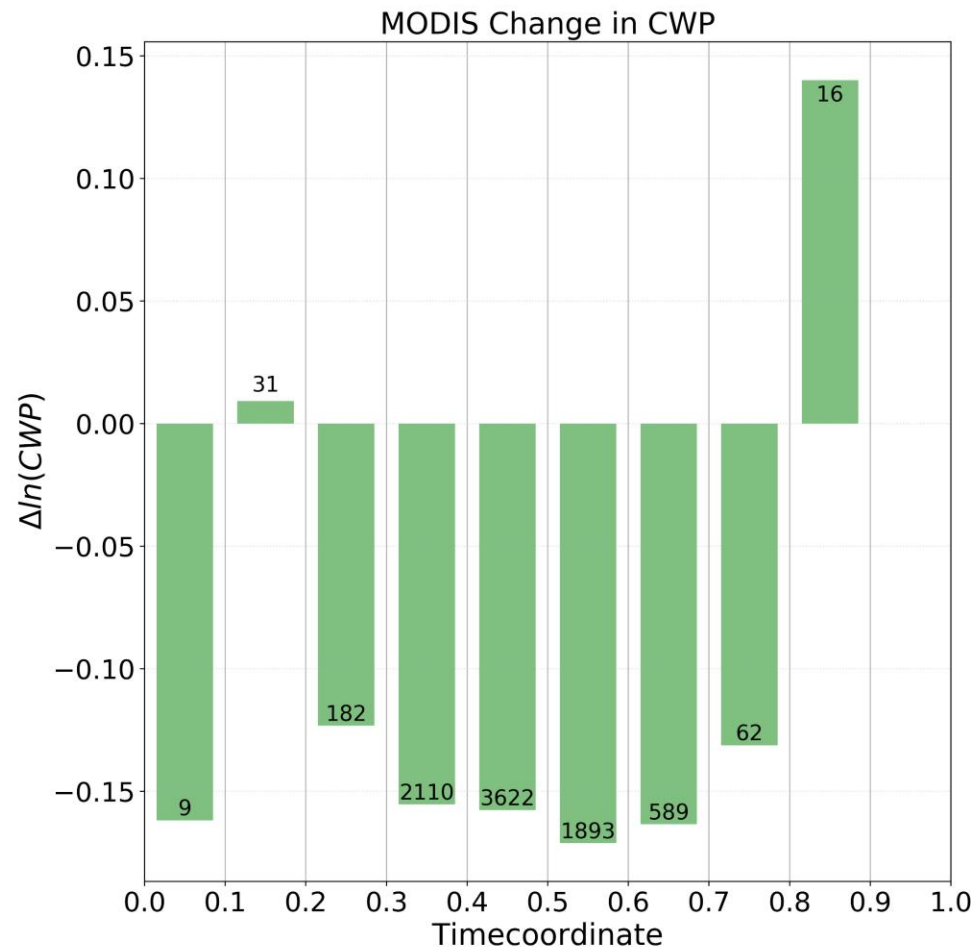


Results

Timecoordinate: 0 – sunrise; 1 – sunset;

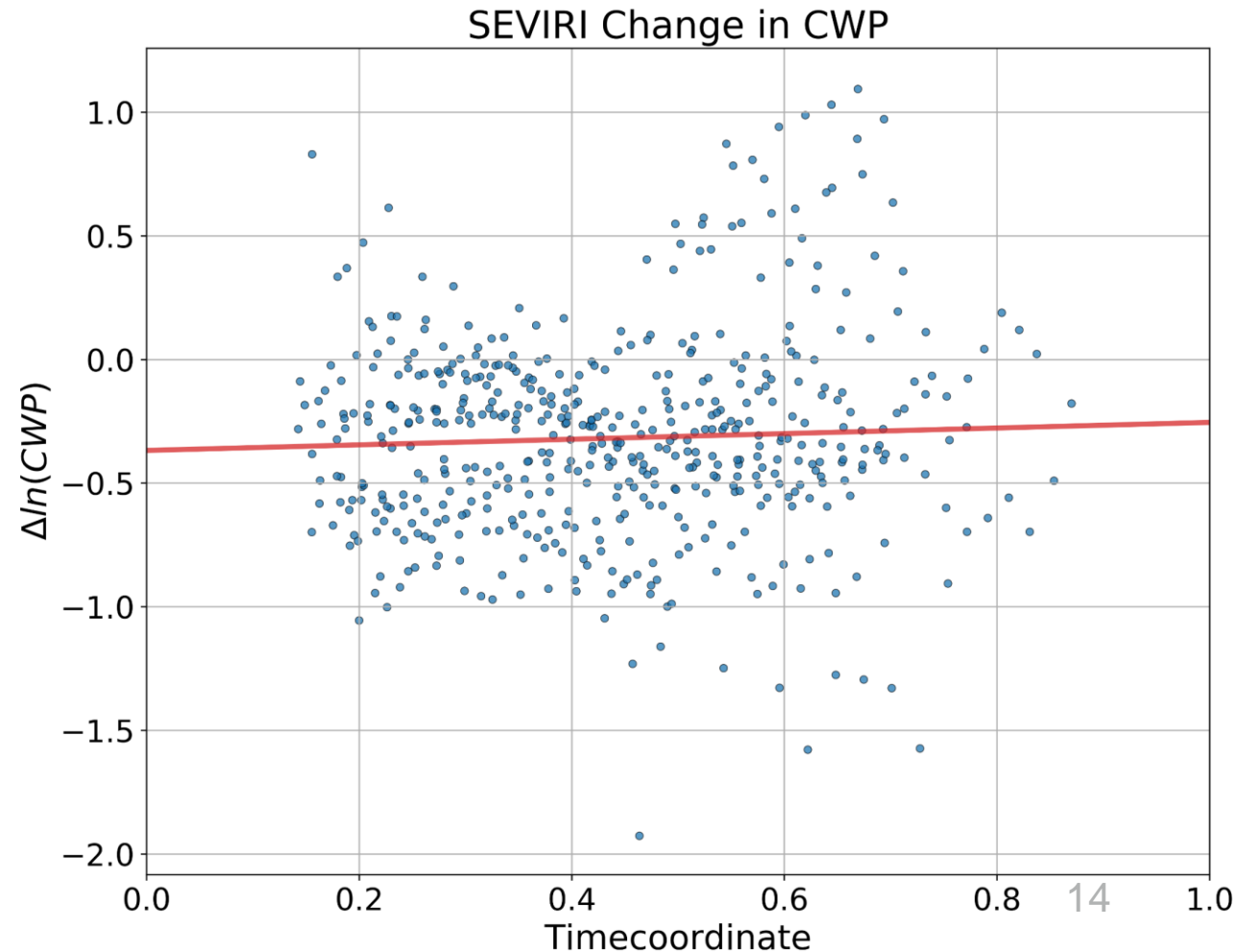
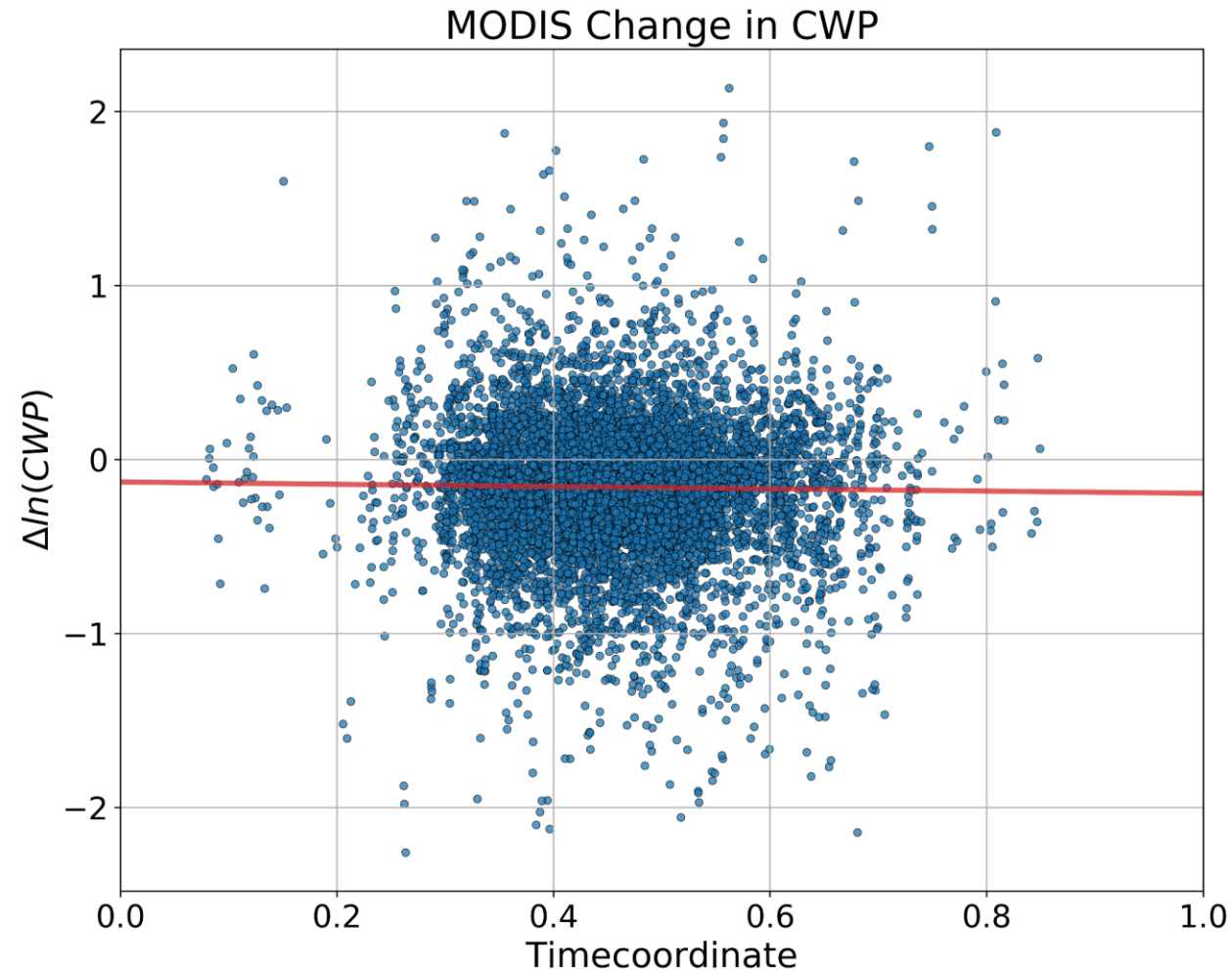
Mean change of CWP during daytime – no significant diurnal behaviour in average data

Results are supported by similar results from a study made using MODIS data



Results

Change in CWP over all cases during daytime – no explicit diurnal cycle in data (also supported by similar results from study using MODIS data)



Conclusion

- No explicit diurnal cycle could be seen from data over land, but clear signal from data over ocean (Diamond *et al.* (see slide nr. 6))
- Mean negative condensed water path values → amount of water is decreasing
 - Needs further investigation with more detailed meteorological data to see what exactly affects the depletion of water from clouds
- The MSG CPP product needs to be checked to see where some occasional erroneous values are coming from