

# A unified global investigation on the spectral effects of soiling losses of PV glass substrates: preliminary results

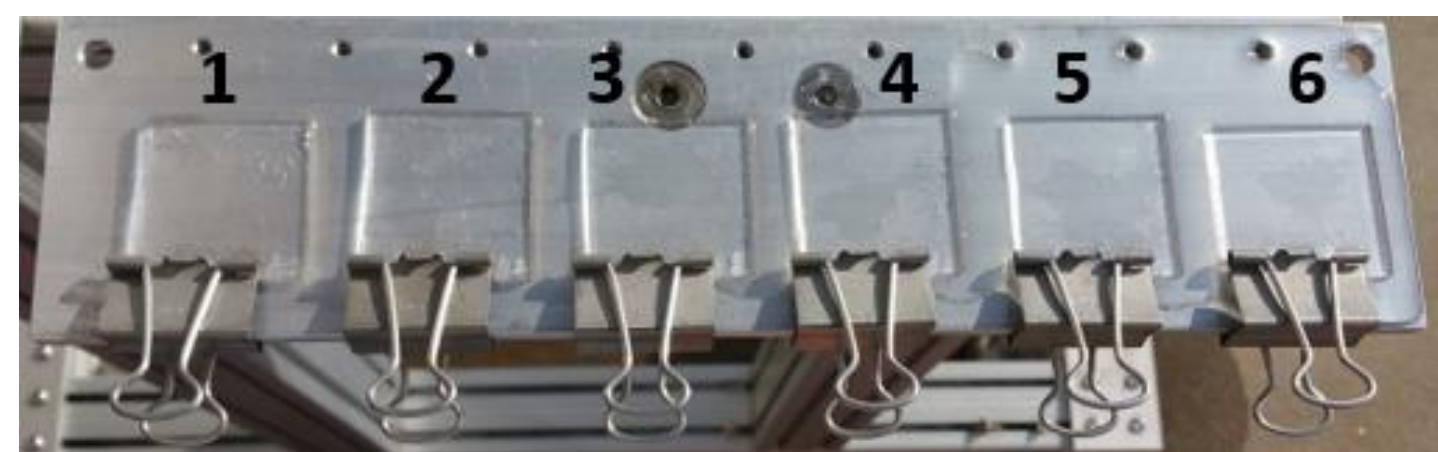
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**AIM:** This work presents the preliminary results of an international collaboration that aims to investigate the spectral effects of soiling naturally deposited on PV glasses installed at various locations worldwide

## PART I: experimental setup

Tests conducted at 8 locations chosen to represent a variety of conditions. Seven identical 4cm × 4cm sized and 3mm-thick low-iron glass were shipped to each location. Six coupons were installed outdoors, at zero tilt angle. One coupon was used to calibrate the different spectrophotometers.



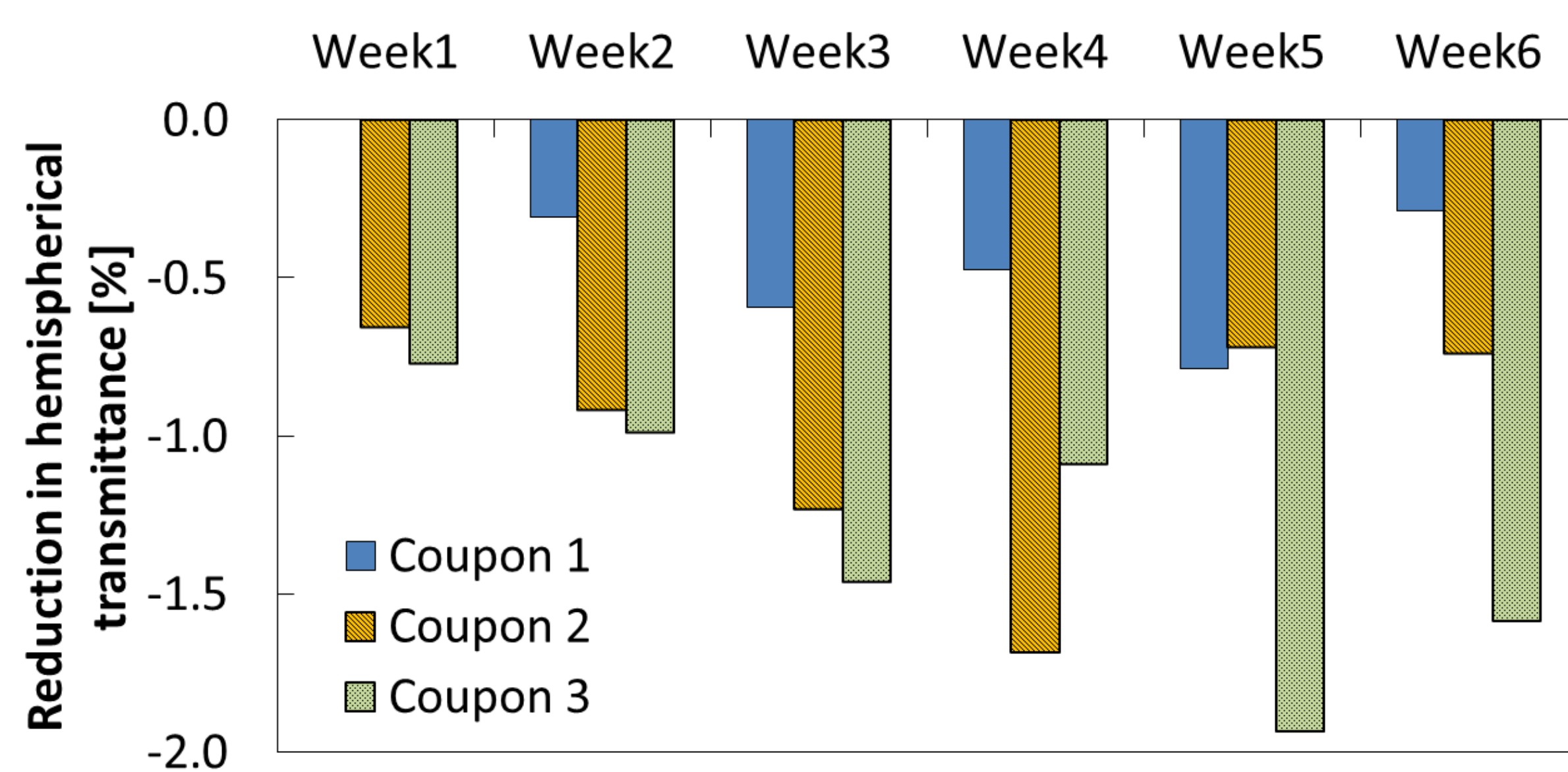
On the left: Supporting structure holding six glass coupons. These are held with binder clips on a horizontally-mounted aluminum plate.

On the right: List of monitored locations and climate classifications.

City, Country	Climate classification
Chennai, India	Equatorial savannah with dry winter (Aw)
Dubai, UAE	Desert climate (Bwh)
El Shorouk City, Egypt	Desert climate (Bwh)
Golden (CO), USA	Snow climate, fully humid (Dfb)
Jaén, Spain	Warm temperate climate with dry summer (Csa)
Penryn, UK	Warm temperate climate, fully humid (Cfb)
San José (CA), USA	Warm temperate climate with dry summer (Csb)
Tezpur, India	Warm temperate climate with dry winter (Cwa)

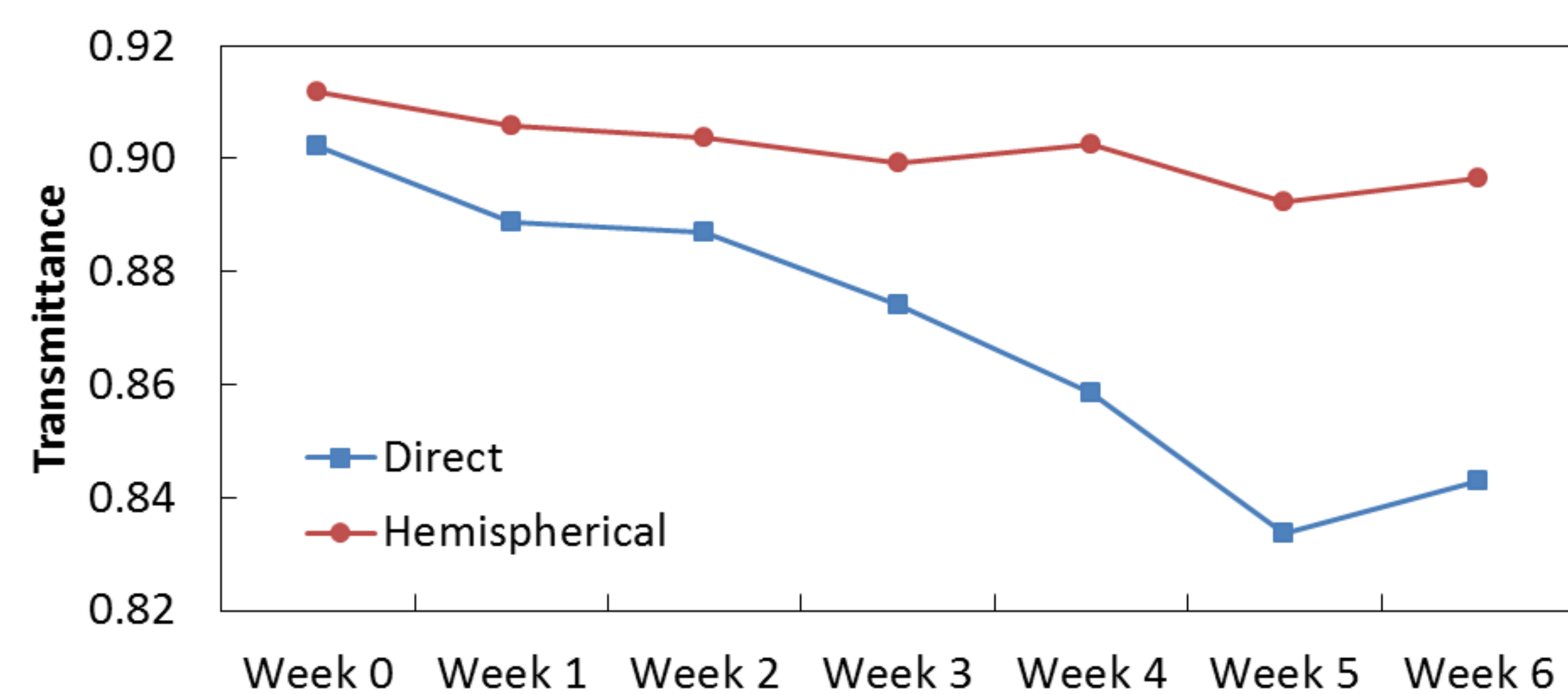
## PART II: data collection (January – March 2017)

Weekly transmission measurements were taken on coupons 1, 2 and 3. Coupon 1 was cleaned weekly, coupon 2 was cleaned every 4 weeks and coupon 3 was never cleaned. A dry cleaning is performed by using a microfiber cleaning cloth.



On the left: Progressive absolute drop in hemispherical transmittance, compared to the initial conditions, registered in Golden, CO. Coupon 1 was manually cleaned every week and coupon 2 was cleaned on week 4.

The effect of the deposits on soiled coupon 3 does not necessarily increase at the same rate as coupon 1, which is cleaned weekly. Indeed, differently soiled coupons can be differently impacted by rainfalls: if soiling has been accumulating for some time, it might be more difficult to wash.

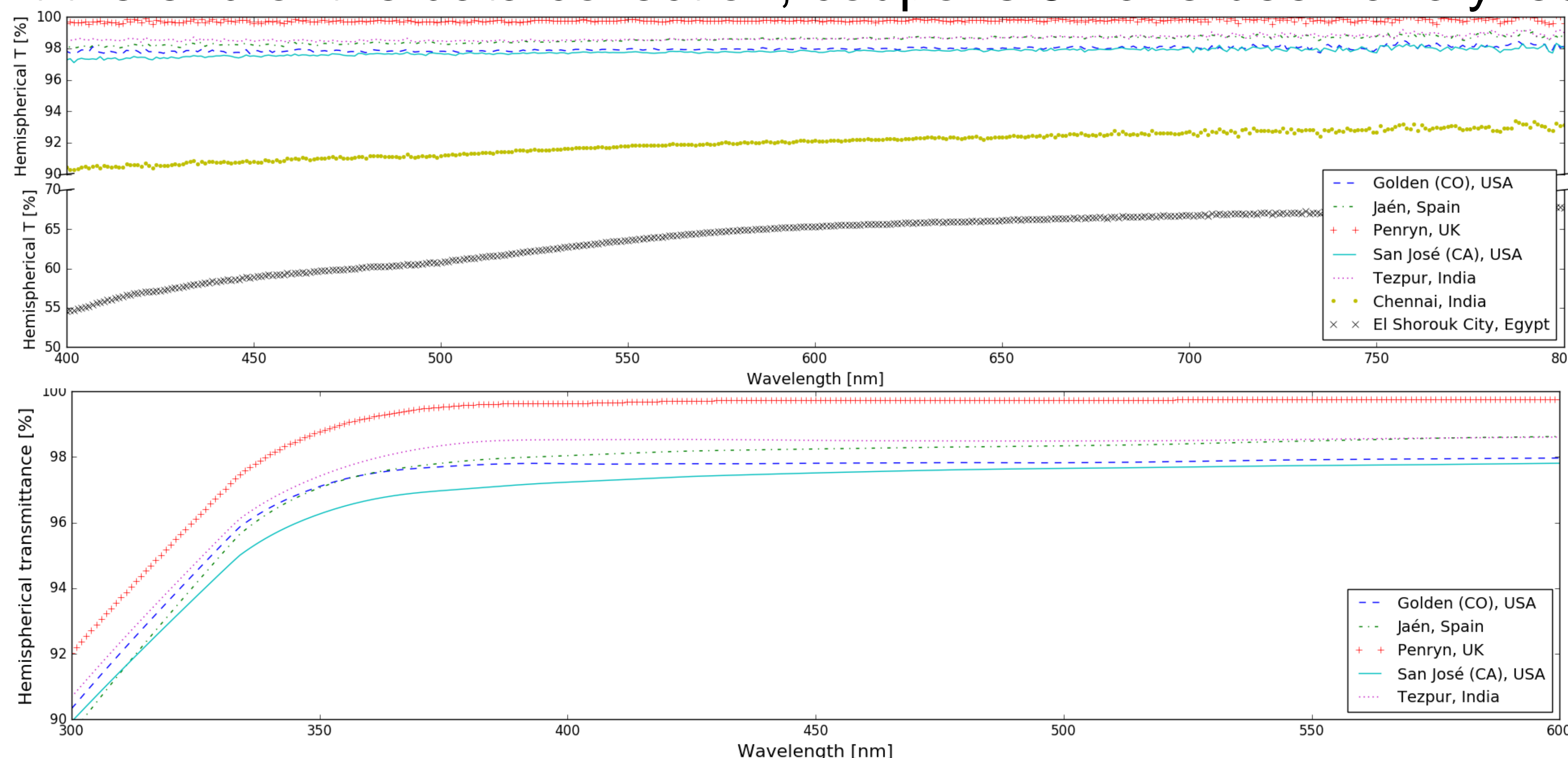


On the left: Direct and hemispherical transmittance of coupon 3 in Golden.

Higher losses have been found when direct %T is considered instead of hemispherical. In the same wavelength range, the direct transmittance drops by 6% in 6 weeks, while the loss in hemispherical transmittance is limited to 1.5%.

## PART III: data analysis and preliminary conclusions

At the end of the data collection, coupons 5 have been analyzed using the same instruments for a consistent comparison.



On the upper left: Hemispherical %T of coupon 5, referenced to the transmittance of coupon 0. Soiling has a higher impact on the blue than on the red end of the spectrum, independently of the location and of the amount of losses.

On the lower left: Hemispherical %T of coupon 5 for five low soiling sites, referenced to the transmittance of coupon 0. All the sites show similar trends at large wavelengths, while different curves are found at wavelengths lower than 500 nm.

On the right: Broadband hemispherical %T, average particle area and percentage of the surface covered by particles. A linear correlation is found between the percentage area covered by particles and the hemispherical transmission.

City, Country	Hemispherical transmittance [%]	Average particle area [ $\mu\text{m}^2$ ]	Area coverage [%]
Chennai, India	84.2	132-168	5.1-8.3
El Shorouk City, Egypt	63.1	110-194	21.3-22.8
Golden (CO), USA	88.8	55-100	1.7-2.4
Jaén, Spain	89.3	33-92	1.3-1.4
Penryn, UK	90.1	N.A.	N.A.
San José (CA), USA	88.5	206-220	1.9
Tezpur, India	89.6	47-60	0.3-0.4