# Radiative Properties of Aerosols and Clouds from Observations and Models over the Southeast Atlantic

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EGU 2020 Virtual Presentation

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# Introduction

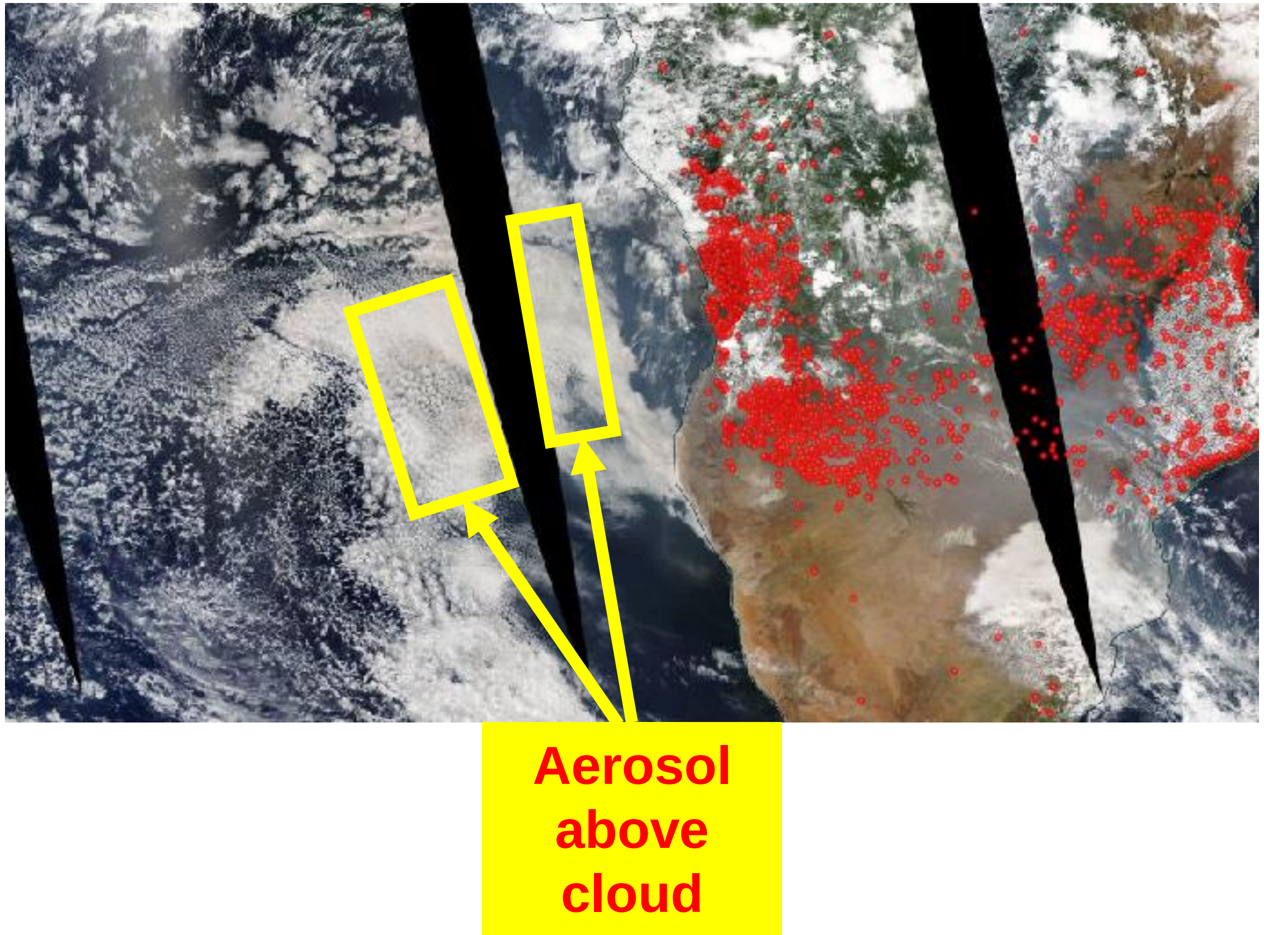
Quantifying above-cloud aerosol optical depth (ACAOD) and underlying cloud optical depth (COD) from observations and chemical transport models remains challenging, complicating the estimate of the aerosol direct radiative effects.

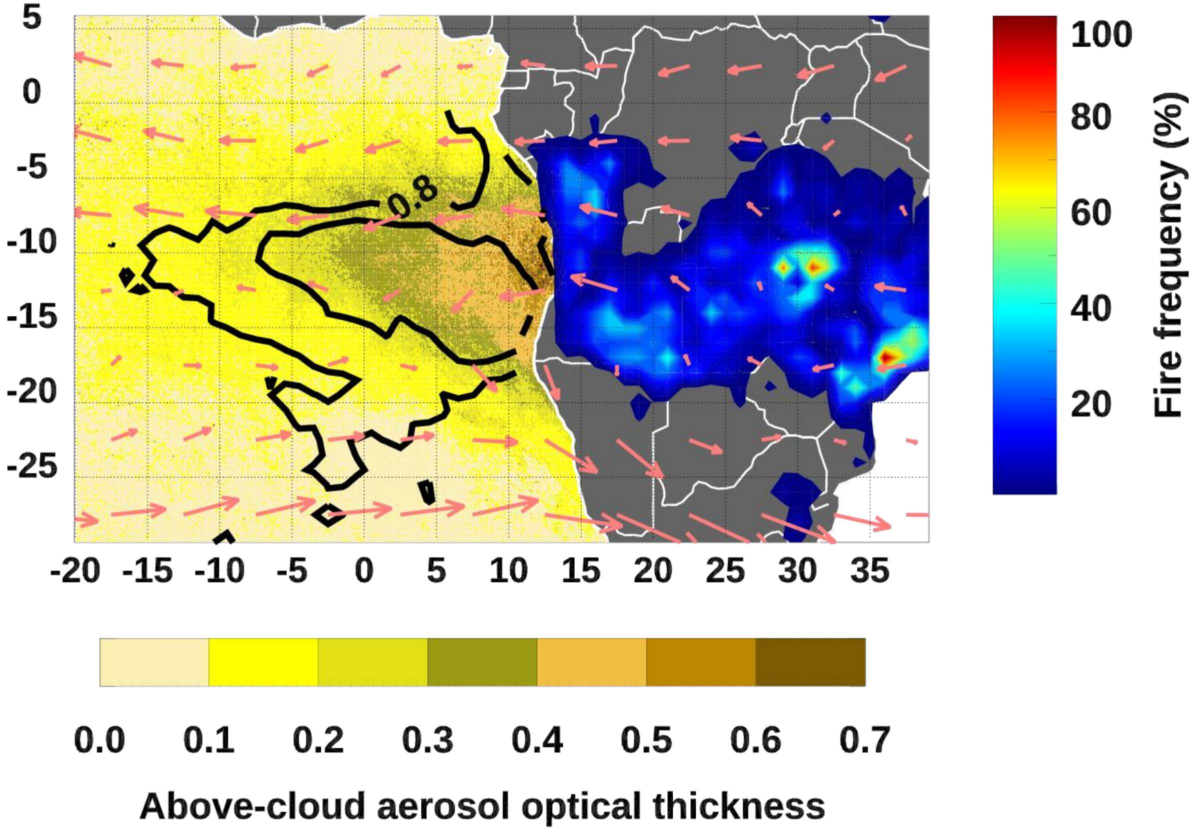
# Objectives

- Evaluate the performance of above-cloud aerosol optical depth (ACAOD) retrievals from satellite and the impact of temporal collocation on the retrieval results.
- Compare cloud optical depth (COD) retrievals between satellite and NASA ORACLES aircraft.
- Evaluate chemical transport model diagnostics of AOD and COD over the southeast Atlantic.

# Study domain: September 2016 in South Atlantic

Aqua true color on 19 September 2016




Yellow to brown shading: above-cloud AOD
Black contours: Cloud fraction
Land shading: Fire frequency
Arrows: wind vectors

# Part 1 results: Satellite and aircraft intercomparisons

# Data Sets

**Aircraft**

**1) 4STAR (Sun-Tracking Atmospheric Research)**

- Hyperspectral AOD (355-1650nm) from sun photometer

**2) HSRL-2 (High Spectral Resolution Lidar)**

- Aerosol extinction at 532 nm and aerosol backscatter and depolarization at 532 and 1064 nm

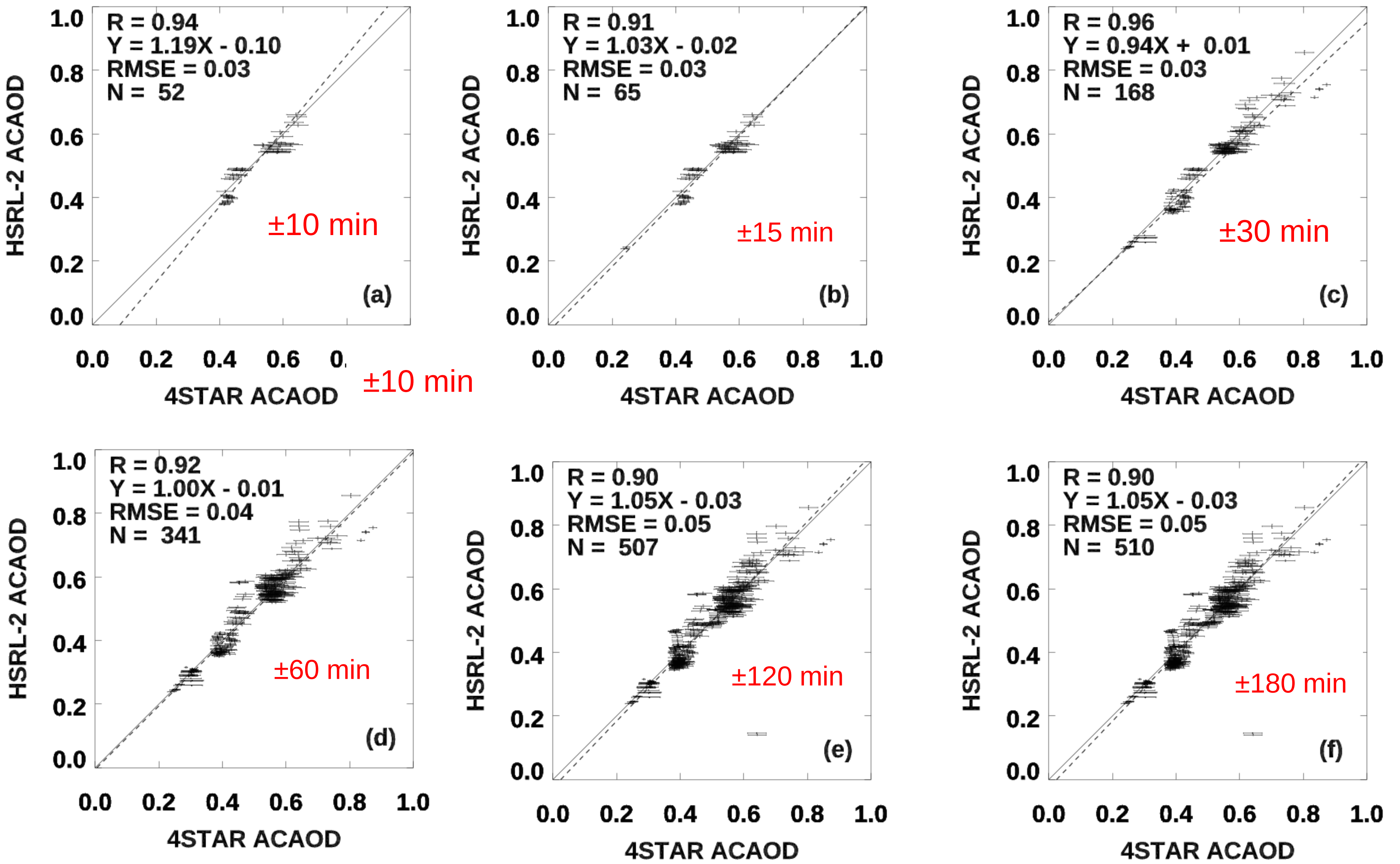
**3) SSFR (Solar Spectral Flux Radiometer)**

- Upwelling / downwelling solar spectral irradiance (350 nm - 2150 nm) to retrieve COD

**Satellite retrievals**

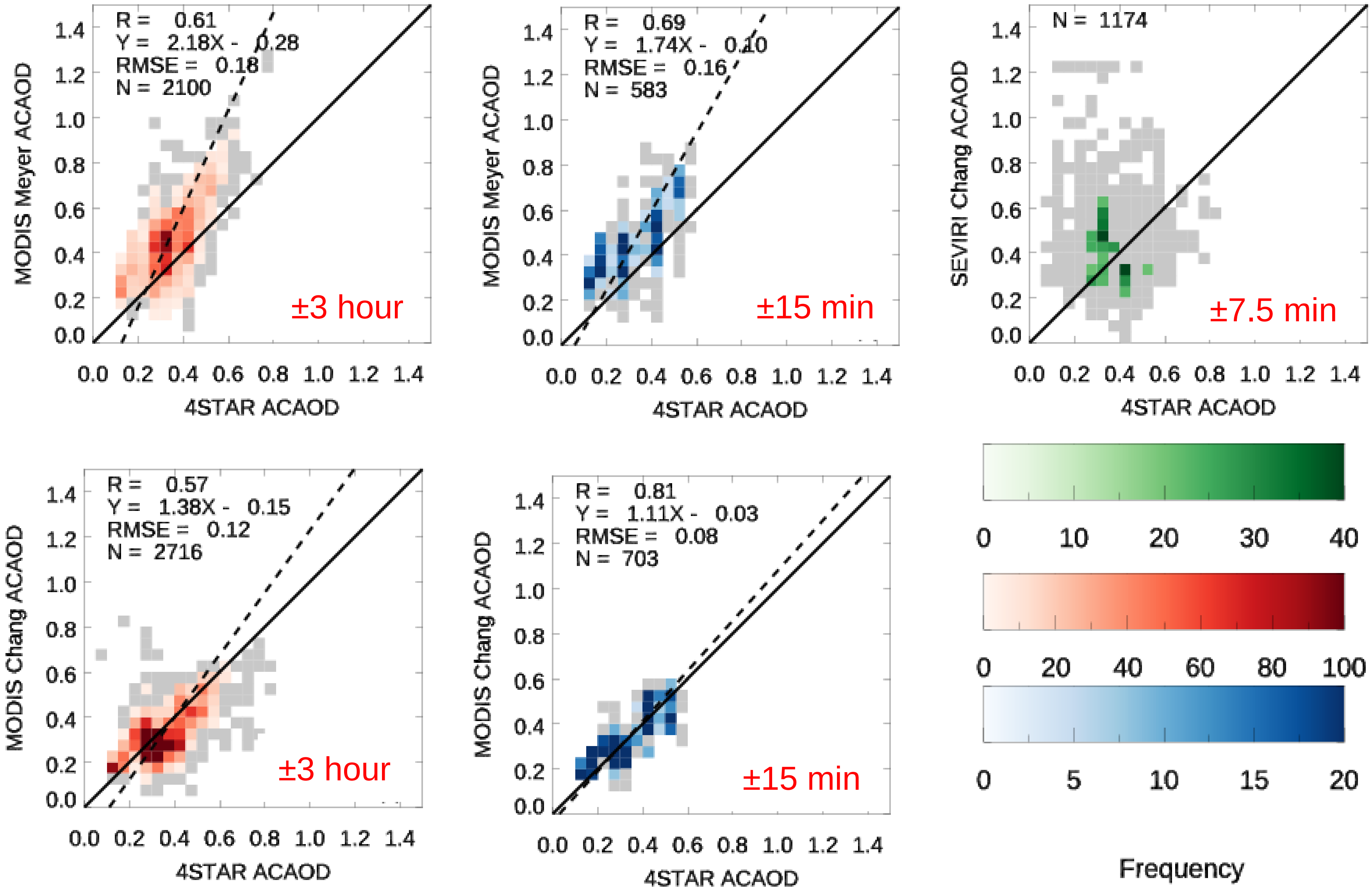
- **Type 1:** Optimal estimation method from six MODIS solar channels (Meyer et al., 2015)
- **Type 2:** MODIS 0.47/0.87µm reflectance ratio (Jethva et al., 2013)
- **Type 3:** SEVIRI 0.64/0.81µm reflectance ratio (Chang and Christopher, 2016)

# Results: 4STAR-HSRL ACAOD comparisons



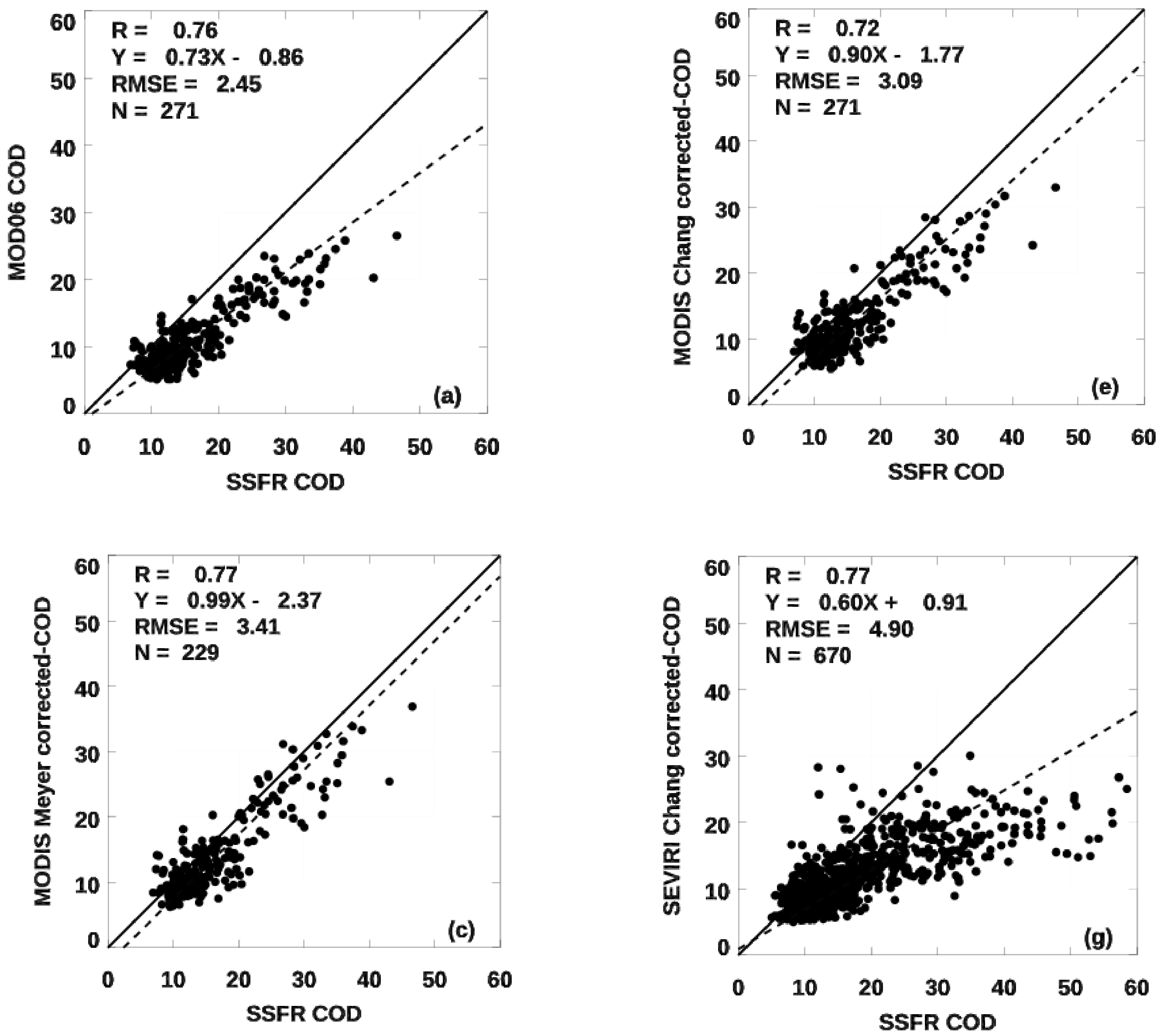

- RMSE increases with coarser temporal collocation due to increased differences in the ACAOD measurements.
- The increased ACAOD differences suggests the presence of aerosol heterogeneity in this region.

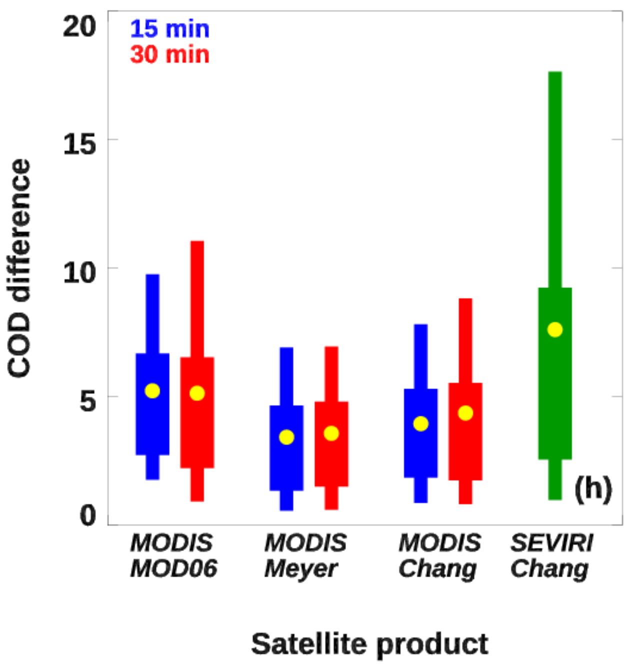
# Results: 4STAR-satellite ACAOD comparisons




Finer temporal collocation improves the retrieval performance both for *R* and *RMSE*

# Results: Cloud optical depth comparisons




- Finer temporal collocation reduces the COD differences between satellite and aircraft retrievals
- SEVIRI still underestimates COD due to its coarser spatial resolution

# Part 2 results: Model and aircraft intercomparisons

# Model Descriptions

**1) WRF-Chem** model that couples with the Community Atmosphere Model version 5 (CAM5) physics package (36-km horizontal grid resolution)

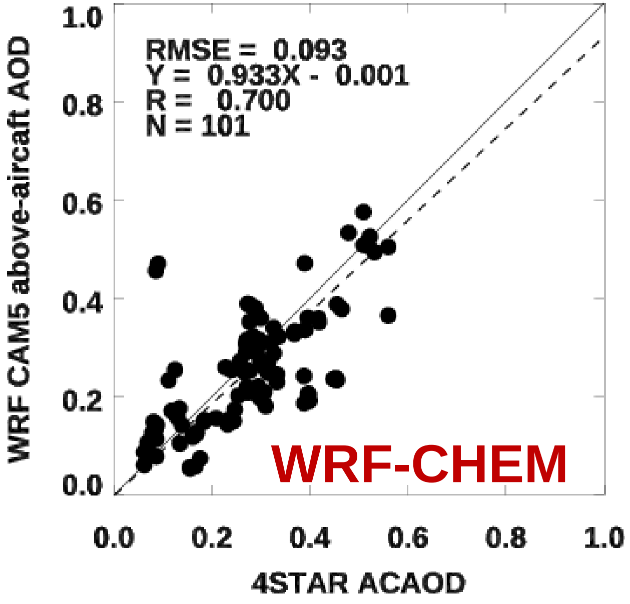
**2) ALADIN**: Regional climate model based on bi-spectral semi-implicit semi-lagrangian model (12 km horizontal resolution)

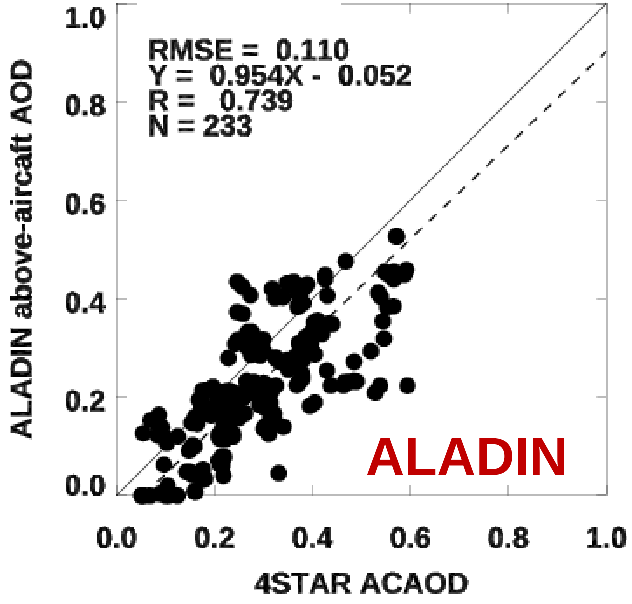
**3) GEOS-5:** The Goddard Earth Observing System Version 5 (GEOS-5) is a global modeling system developed at NASA Global Modeling and Assimilation Office (GMAO)(25 × 31.25 km horizontal resolution)

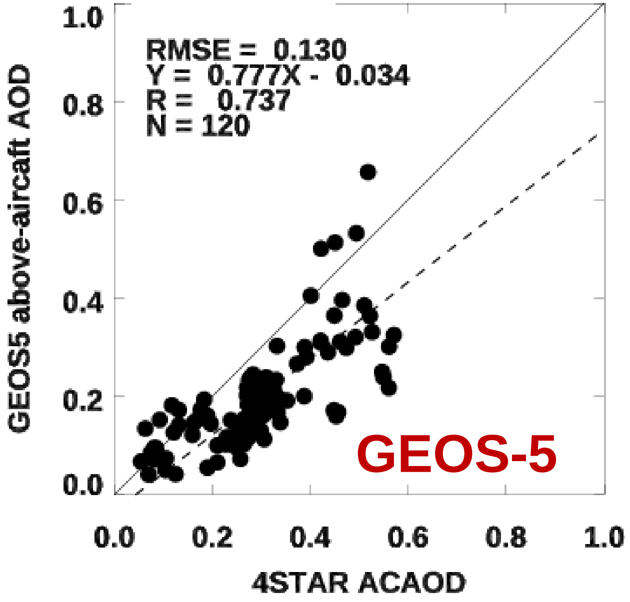
**4) GEOS-CHEM:** A global 3-D model of 9 atmospheric composition driven by assimilated meteorological data GEOS-FP data from the GMAO (25 × 31.25 km horizontal resolution)

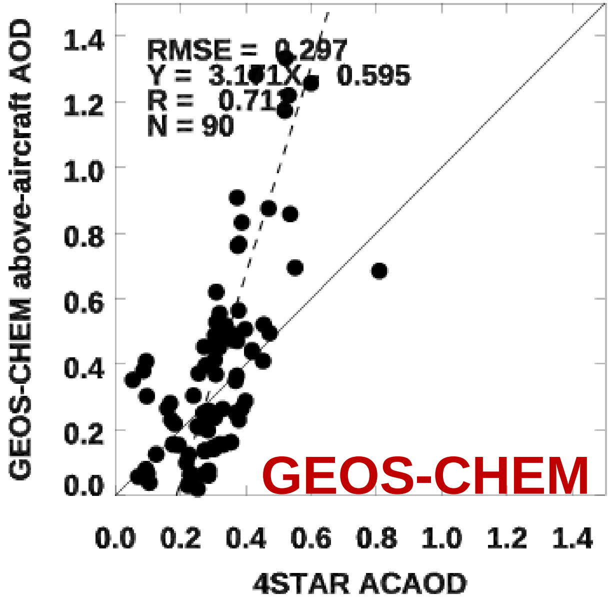
**5) MERRA-2**: Modern-Era Retrospective-analysis for Research and Applications- Version 2 uses GEOS-5 that is radiatively coupled to GOCART (50 × 61.25 km horizontal resolution)

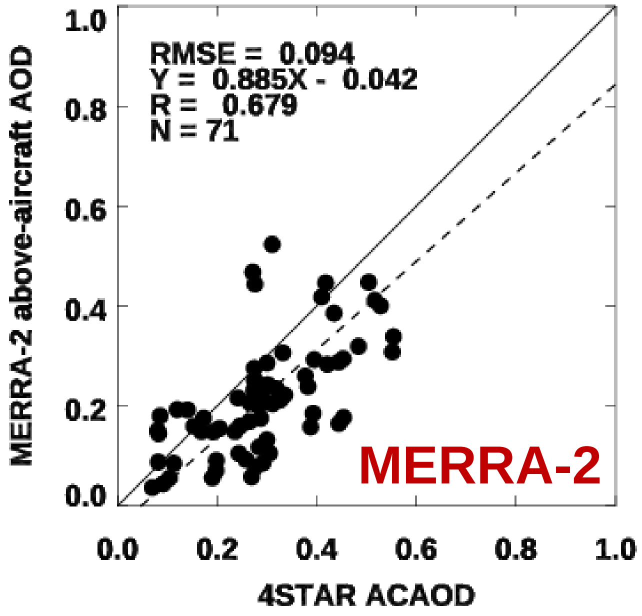
# Results: ORACLES 2016 aircraft-model AOD



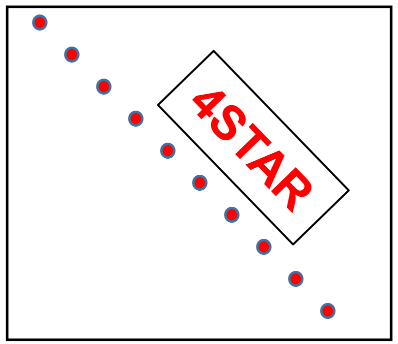



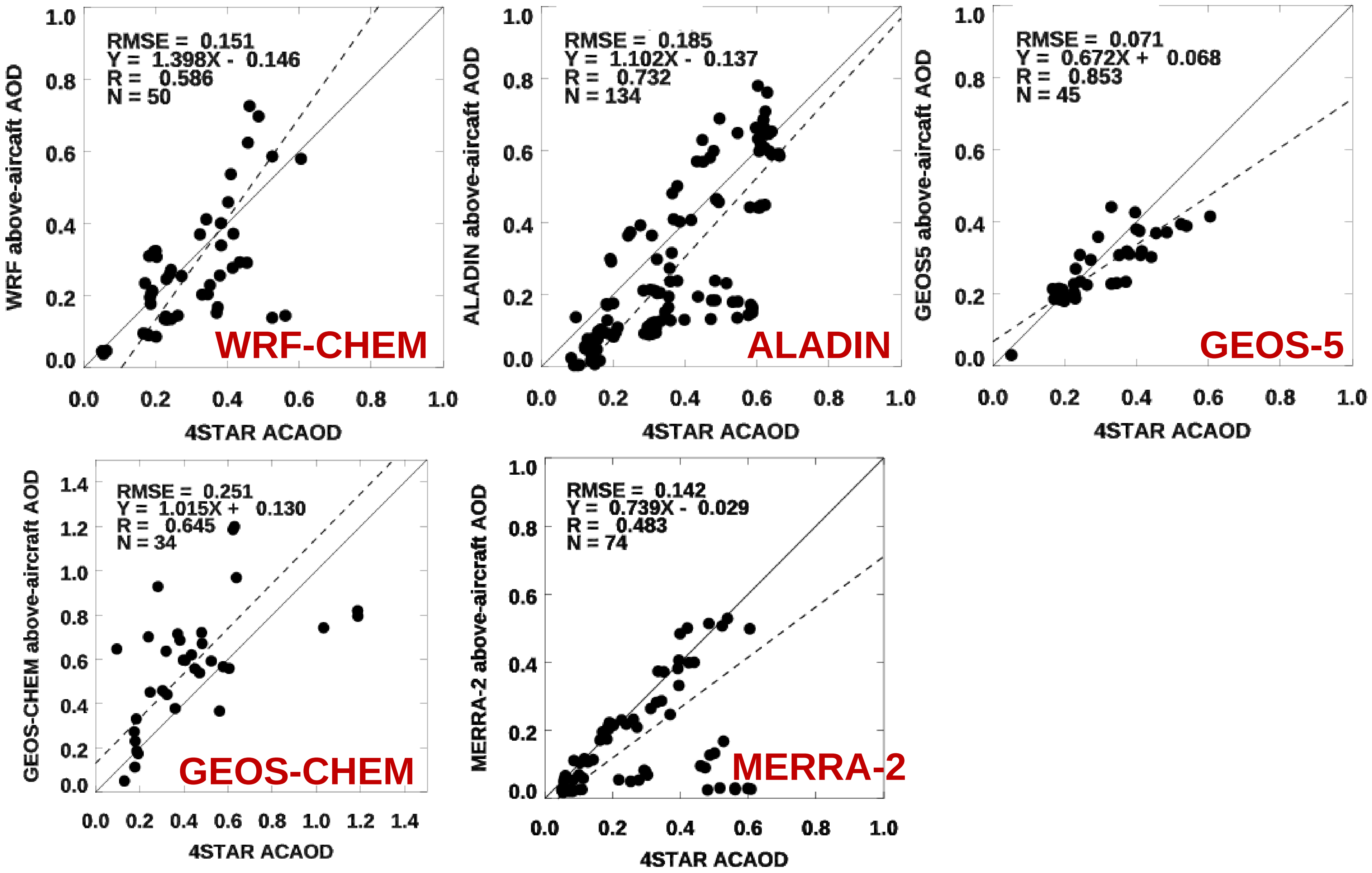




±30-minute collocation



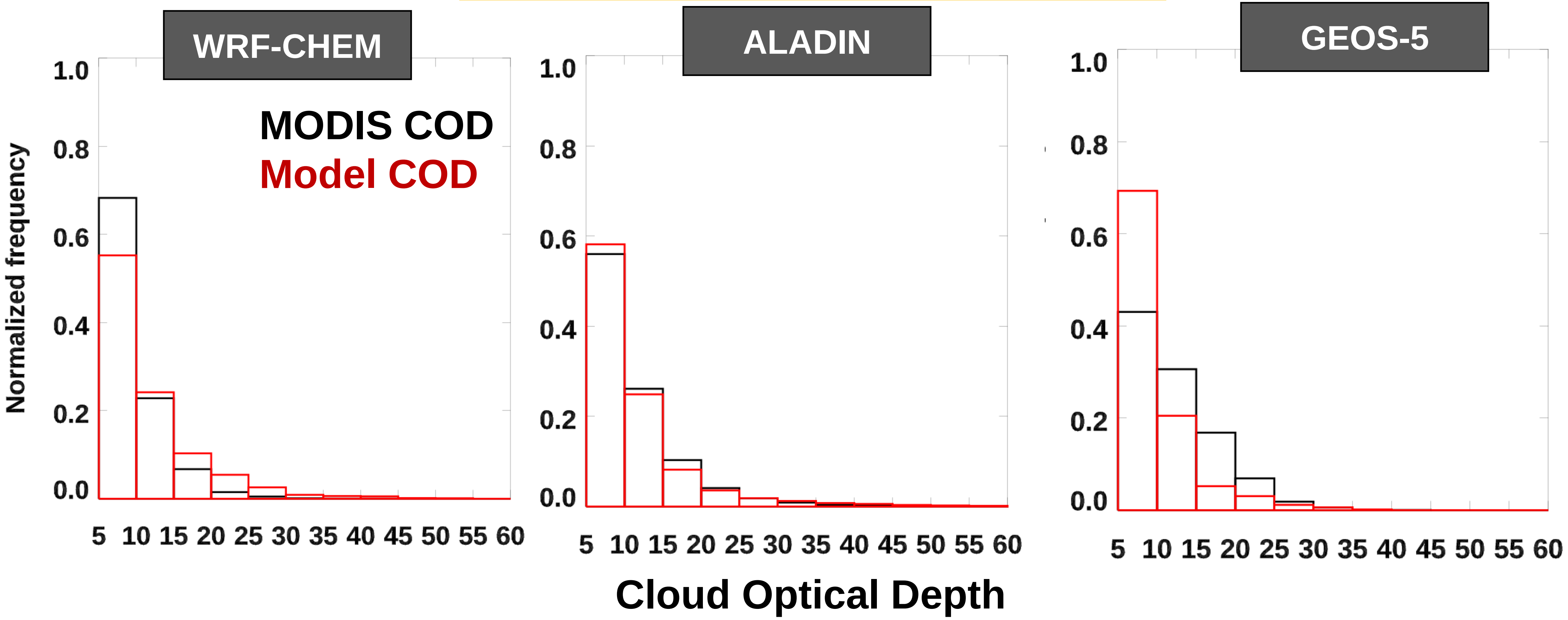

Example of one model grid

# Results: ORACLES 2017 aircraft-model AOD



# Results: 10° × 10° COD Frequency Distributions (Sep 2016)

Domain: 5°E to 15°E, 20°S to 10°S



# Summary and future work

- ACAODs over the southeast Atlantic shows heterogeneity beyond 15 minutes, implying that polar-orbiting satellite retrievals need to impose stringent temporal collocation.
- Correction to CODs due to overlying aerosol attenuation has shown to be comparable to aircraft COD retrievals.
- Models and 4STAR AODs have a higher agreement during 2016 than during 2017. Major sources of model uncertainties need to be diagnosed.
- Models tend to produce optically thicker low-level liquid clouds than satellite-retrieved CODs over the southeast Atlantic.
- Future work needs to revisit the direct aerosol radiative effects in southeast Atlantic. The impact of mid- and high-level clouds on satellite retrievals of underlying aerosols is under investigation.

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