

# Seasonal Predictability of Cloud Droplet Number Concentration

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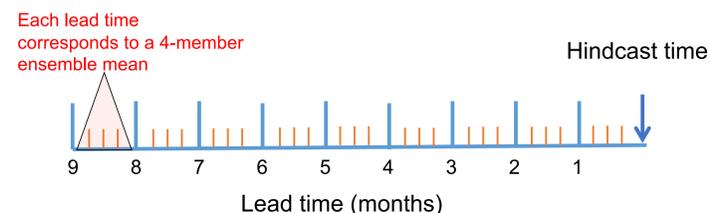
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## Motivation

Aerosol emissions modify the properties of clouds hence impacting climate. The aerosol indirect effect may have offset part of the global warming caused by anthropogenic greenhouse gas emissions during the industrial era. It however remains unclear whether the same effect is significant over time scales relevant for seasonal and subseasonal climate prediction. Answering such a question has been difficult since most weather prediction systems lack a proper representation of the aerosol evolution and transport and their interaction with clouds. Even in advanced systems it is not clear to what extent cloud microphysical properties are predictable over subseasonal to seasonal time scales.

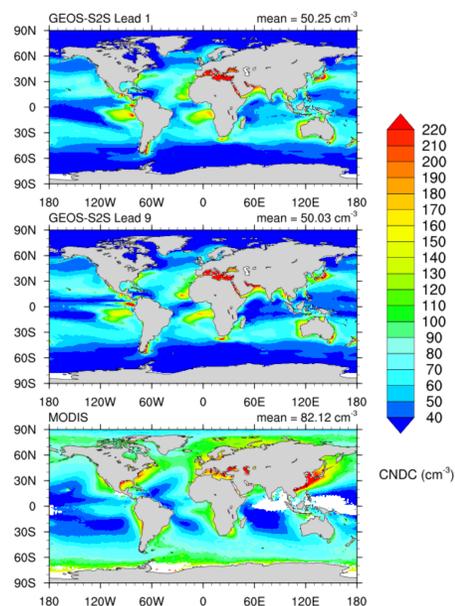
## Hindcast Simulations

We use a set of 35 year (1980-2015), four ensemble member, 9 month lead hindcast (initialized using MERRA-2, Gelaro et al. 2016) simulations of the NASA GEOS seasonal prediction system (GEOS-S2S) to study the predictability of cloud droplet number concentration in warm stratocumulus clouds. GEOS-S2S is an atmosphere-ocean coupled system used operationally for seasonal prediction at the spatial resolution of 0.5°. The latest version GEOS-S2S system implements interactive aerosol transport as well as a two-moment cloud microphysics scheme (Barahona et al. 2014) therefore it is suitable for studying the effect of aerosol-cloud interactions on climate.



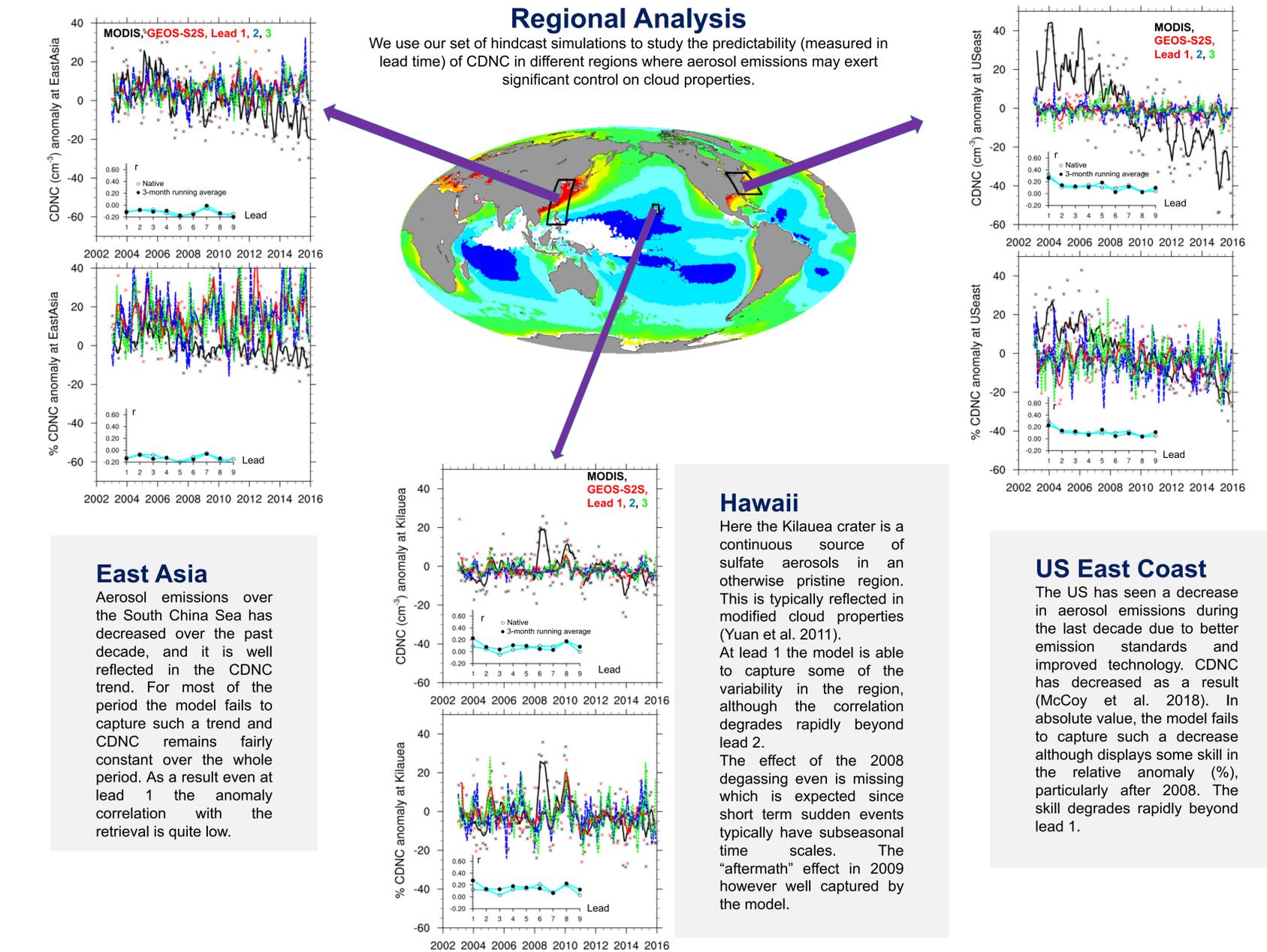
## Global Mean Cloud Droplet Number Concentration

Each lead time produces a 4-member ensemble mean of CDNC over the whole 35 year period. The comparison against MODIS-retrieved CDNC (Bennartz, et al. 2017) suggest a reasonable skill of the model in reproducing the global mean CDNC with notable exceptions in the Arctic and Antarctic regions.



Global Mean CDNC changes very little between time leads 1 and 9.

Sampling of the model may bias the satellite-model comparison since only adiabatic extended stratocumulus are included in the retrieval.



## Conclusions and Outlook

In general GEOS-S2S was able to capture the main features of the global distribution of CDNC, independently of lead time.

Underprediction in CDNC was found in the Arctic and Antarctic regions and in the high-latitude regions. This could be ascribed to overactive freezing in GEOS-S2S which tends to thin mixed-phase clouds (Vergara-Temprano et al. 2017).

The analysis of the time series of CDNC in three aerosol-impacted regions of the world indicated no predictability in CDNC after lead time 1. This means that aerosol-cloud interactions may have little effect over seasonal scales although it could be also attributed to the onset of other confounding factors (i.e., meteorology) which could mask the aerosol effect on clouds. Discrepancy between the sampling of the model results and the retrieval assumptions, and model errors, may also affect the comparison.

At lead time 1 the model showed some skill in reproducing the MODIS anomaly, although it failed at reproducing long term CDNC tendencies in polluted regions. Since MERRA-2 is able to reproduce such trends (McCoy et al. 2018), the lack of skill may be the result of an initialization protocol that does not included assimilated aerosol.

