Seasonal Variations of Cloud Radiative Effects over the South China Sea in CERES Observation, ERA5 Reanalysis, and TaiESM1

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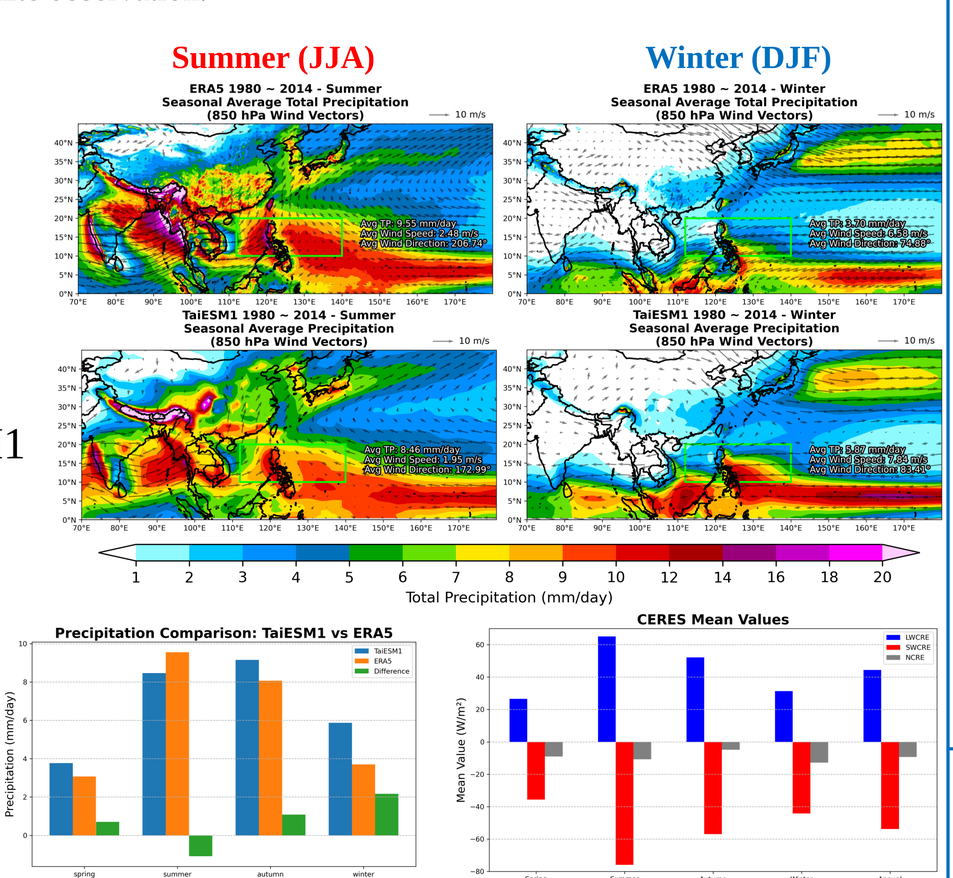
Motivation:

The **South China Sea (112°E ~ 140°E , 10°N ~ 20°N)** experiences strong seasonal variations in precipitation and wind associated with the East Asia Monsoon. These variations also affect cloud radiative effects (CREs). This study examines the seasonal characteristics of CREs in ERA5 reanalysis and TaiESM1 simulation against CERES satellite observation.

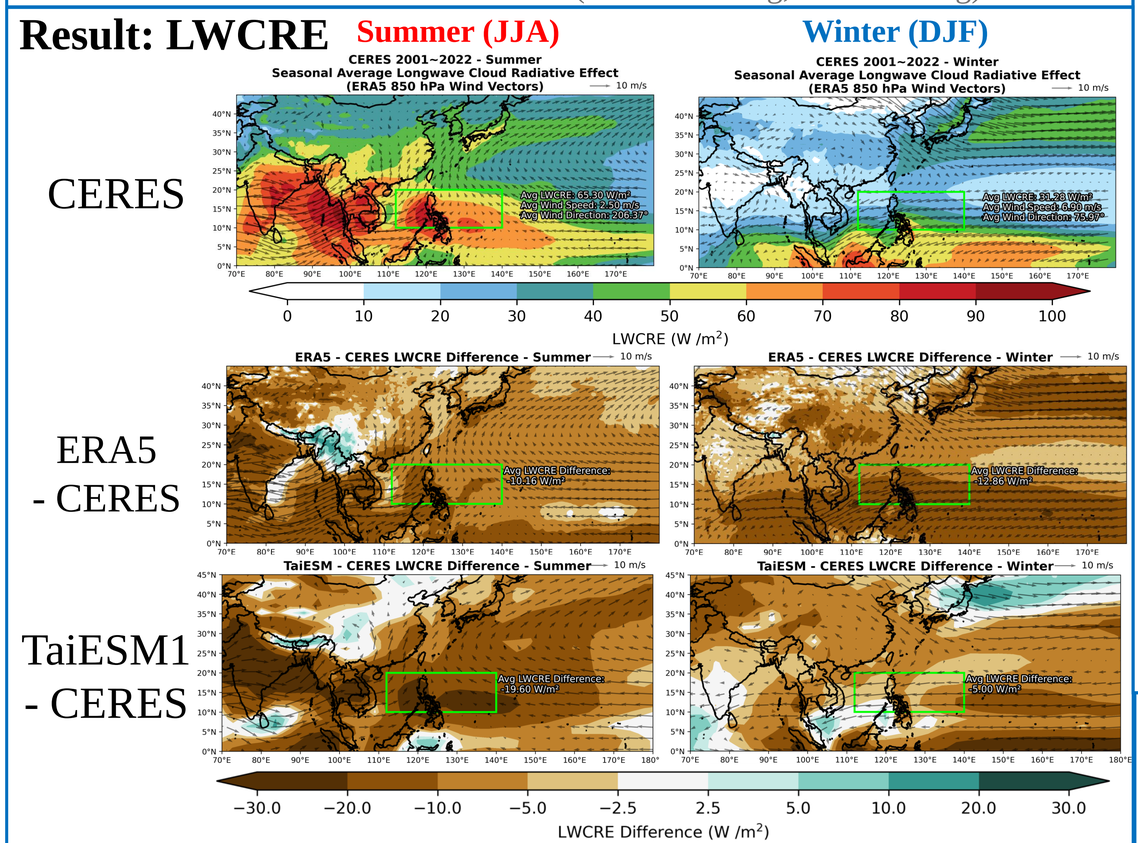


Datasets:

Dataset	Time Coverage	Variables
CERES	**22 years (2001 ~ 2022)**	**TOA radiative fluxes**
ERA5	**35 years (1980 ~ 2014)**	**TOA radiative fluxes , rainfall, wind, and cloud fields**
TaiESM1	**35 years (1980 ~ 2014) (historical simulation)**	**Same as ERA5**

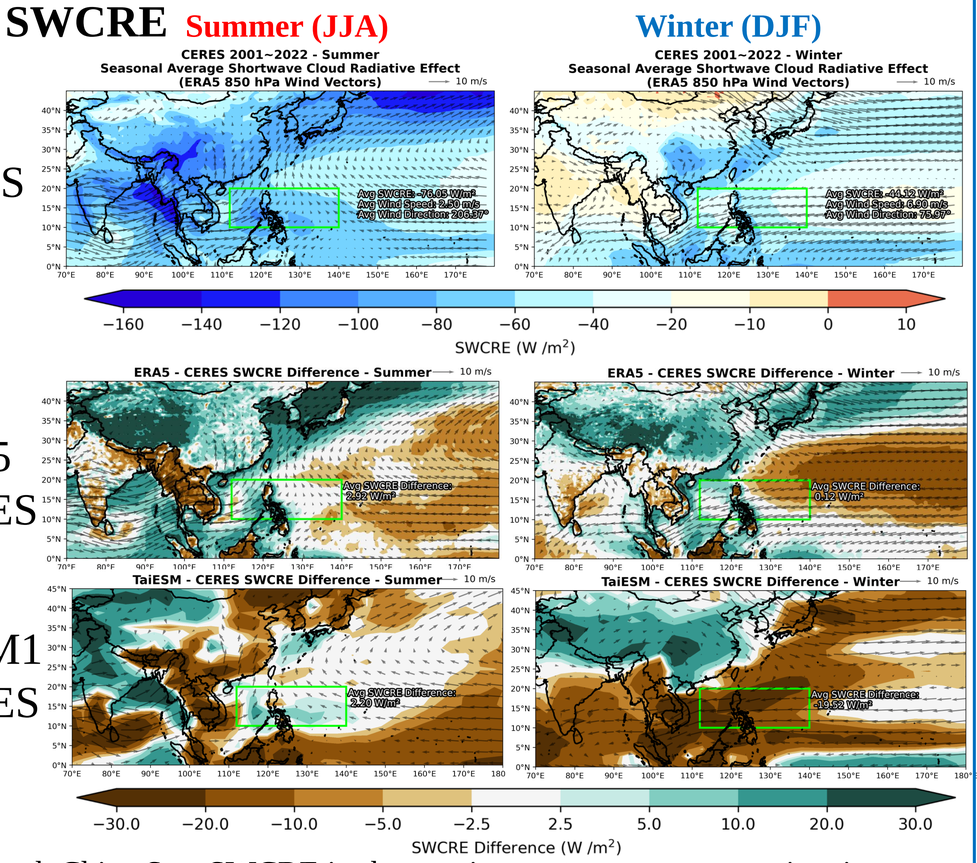
- **LWCRE = TOA LW (↑) clear sky – TOA LW (↑) all sky**
- **SWCRE = TOA SW (↑) clear sky – TOA SW (↑) all sky**
- **NCRE = LWCRE + SWCRE**
  - * LWCRE: Longwave Cloud Radiative Effect (+: warms earth, -: cools earth)
  - * SWCRE: Shortwave Cloud Radiative Effect (+: warms earth, -: cools earth)
  - * NCRE: Net Cloud Radiative Effect (+: net warming, -: net cooling)

Result: LWCRE



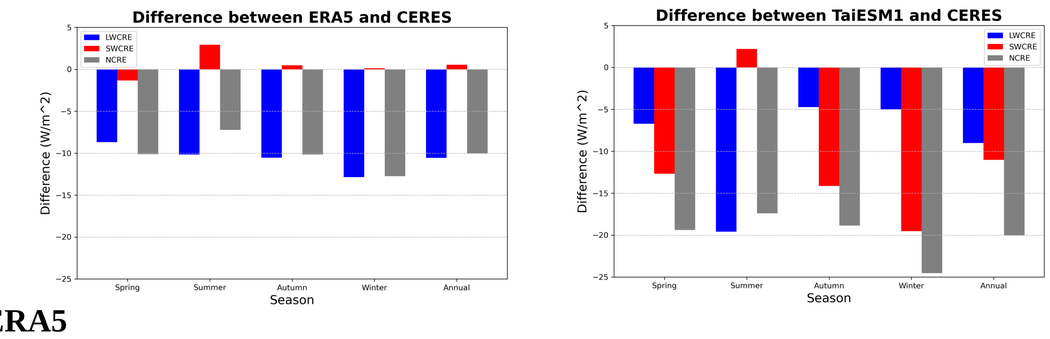
- In the South China Sea, LWCRE is about twice as strong in summer as in winter.
- Both ERA5 and TaiESM1 underestimate LWCRE

Result: SWCRE



- In the South China Sea, SWCRE is about twice as strong summer as in winter.
- Both ERA5 and TaiESM1 quantitatively reproduce the SWCRE features, although TaiESM1 has too strong SWCRE in winter

Result: CRE biases in ERA5 and TaiESM1



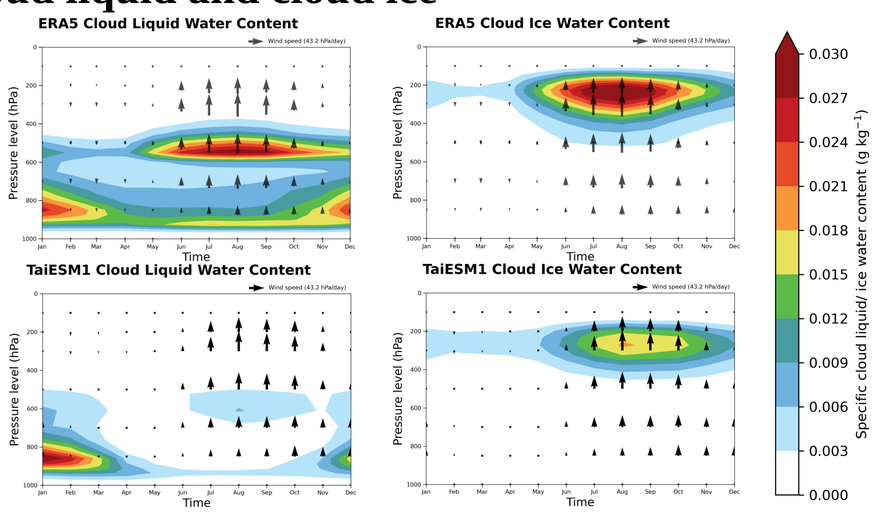
ERA5

- SWCRE is reproduced in the South China Sea in all seasons
- LWCRE is underestimated by ~ 10 W/m^2 in all seasons.

TaiESM1

- SWCRE is overestimated by 10 ~ 20 W/m^2 in all seasons except summer
- LWCRE are slightly weaker in all seasons, except in summer when it is largely underestimated by ~ 20 W/m^2 .

Result: cloud liquid and cloud ice



- Both ERA5 and TaiESM1 show similar cloud features with low clouds dominating in winter and high clouds dominating in summer.
- Compared to ERA5, TaiESM1 has less cloud liquid and ice in all months except winter.
- In TaiESM1, the SWCRE biases in winter may be due to an excess of low clouds, while LWCRE biases in summer may be due to insufficient high clouds.

Conclusion

- Both ERA5 and TaiESM1 can reproduce the seasonal variations in cloud radiative effects in the South China Sea.
- ERA5 underestimates LWCRE by ~ 10 W/m^2 in all seasons
- TaiESM1 largely underestimates LWCRE in summer and overestimates SWCRE in winter.