Impact of clouds on GRUAN observations - need to adjust the uncertainty calculation?

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<u>Significance of Cirrus Radiative Forcing</u>

- The WMO established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to understand climate change

- **Cirrus clouds play a crucial role** in regulating Earth's temperature by reflecting and absorbing sunlight

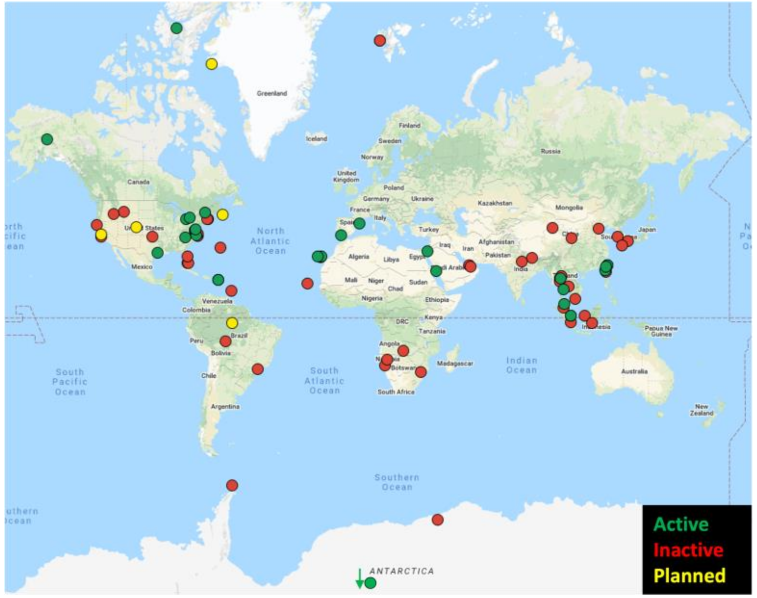
- The behavior of clouds and aerosols in climate models is challenging => <u>varying factors such as location and atmospheric conditions</u>

- Improved understanding of the role of clouds in the climate system **is necessary** to improve the accuracy of climate predictions

Micro-Pulse Lidar Network (MPLNET)

MPLNET is a federated network of Micro-Pulse Lidar (MPL) systems designed to measure aerosol and cloud vertical structure, and boundary layer heights

- Continuous (day/night) operations since 2000 (polarized since ~2016)
- Most MPLNET sites are co-located with NASA Aerosol Robotic Network (**AERONET**) sites and contribute to the World Meteorological Organization (**WMO**) Global Atmospheric Watch (**GAW**) Aerosol Lidar Observation Network (**GALION**)



Recent scientific focus: radiative importance of cirrus clouds

- *Hypothesis:* Gradient in net top-of-atmosphere cirrus radiative forcing (TOA CRF) from equator to the poles due to dependence on cloud micro & macro-physics, solar geometry, surface albedo
- Trilogy of papers on net daytime top-of-atmosphere cloud radiative forcing (GSFC, Singapore, Fairbanks): *Campbell et al. 2016, 2021; Lolli et al. 2017*
    - Lidars like MPLNET and CALIOP have shown that cirrus clouds occur twice as much as previously thought and skew heavily toward low cloud optical depths
    - Consistent with the hypothesis, positive forcing exists over land at the equator (Singapore). However, regional weather variability and fewer daytime hours during winter leads to more positive forcing than presumed in the subarctic (Fairbanks).
- These results help us better understand climate and provide ground-truth verification for satellite observations (e.g. MODIS, CALIPSO, EarthCARE, AtmOS)
- These efforts also led to the development of a unified physical ice parameterization that links ice cloud extinction to particle size (*Dolinar et al. 2022)*
    - Absolute daytime TOA net CRF is more negative using new parameterizations
    - Future studies will reevaluate MPLNET-derived TOA CRF using the new parameterization in comparison with satellite-derived values

FU-LIOU-GU Radiative transfer model

- Gamma weighted 2-stream (SW)S.Kato , 2/4 stream (LW)Q.Fu
  - Inhomogeneous clouds in SW
- 29 bands : 15 SW, 14 LW , 3 of 14 LW in WN
- Shortwave: (0.17 - 4.0)um (2500-57000cm-1)
  - Hitran 2000 (H20) (O2,CO2,CH4) fixed : H20 continuum
  - JPL(1994) O3 uv , WMO(1985) O3 vis
- Longwave (0-2850cm-1) (3.5um – infinity)
  - H20 CO2 O3 N20 CH4 CFCs
  - H20_Continuum(Kratz&Rose)
- Cloud Optical Properties Water (Y.Hu) Ice (Q.Fu)
- Aerosol optical properties
  - OPAC, Tegin&Lacis, D'Almedia, Lacis(2004)Dust

FU-LIOU-GU Radiative transfer online model options

- Atmosphere options
  - Standard (tropical,MLS,MLW,SAS,saw)
  - Column PW ,O3 changes , skin temperature
  - User input of p(z),t(z),h2o(z),o3(z) =>>> GRUAN (no O3)
- Surface Radiative properties
  - Ocean Z. Jin COART surface albedo 0.12 Urban
  - Ceres SARB IGBP land type spectral albedos and emissivity
- Outputs
  - Table of broadband TOA and SURFACE , SW & LW
  - Vertical flux profiles (coarse 4 levels or fine 120 levels)
  - Spectral SW { TOA albedo , surface transmission,sfc albedo}
  - Spectral LW { TOA flux , surface flux }
  - Longwave anisotropy
  - Detailed but cryptic list of all inputs & outputs

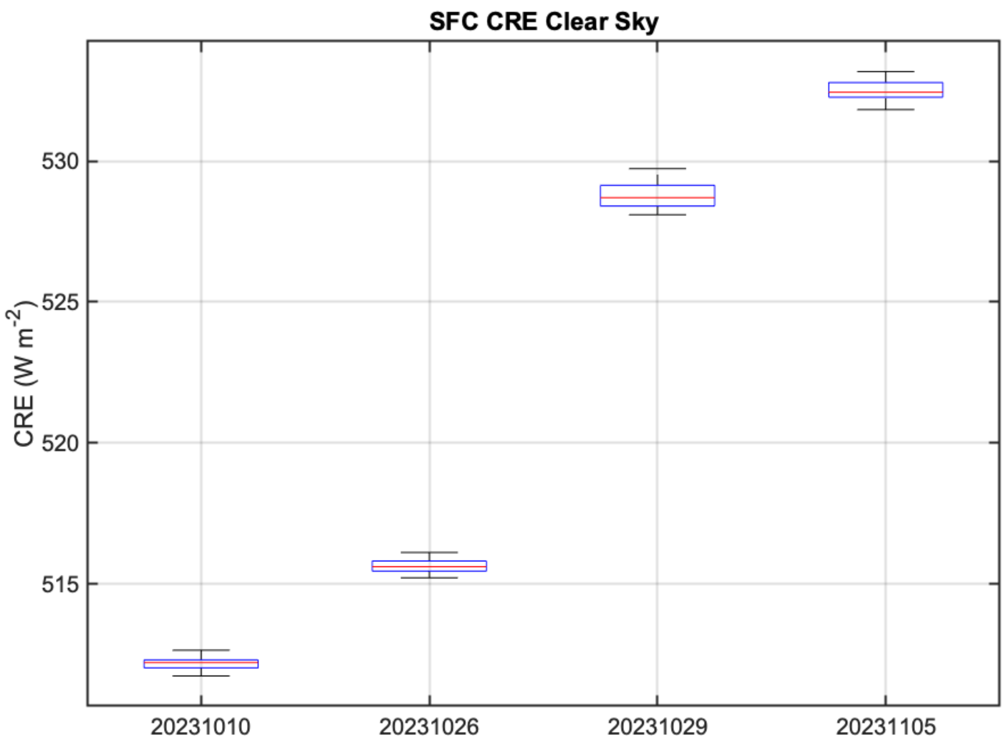
FU-LIOU-GU Radiative transfer online model options

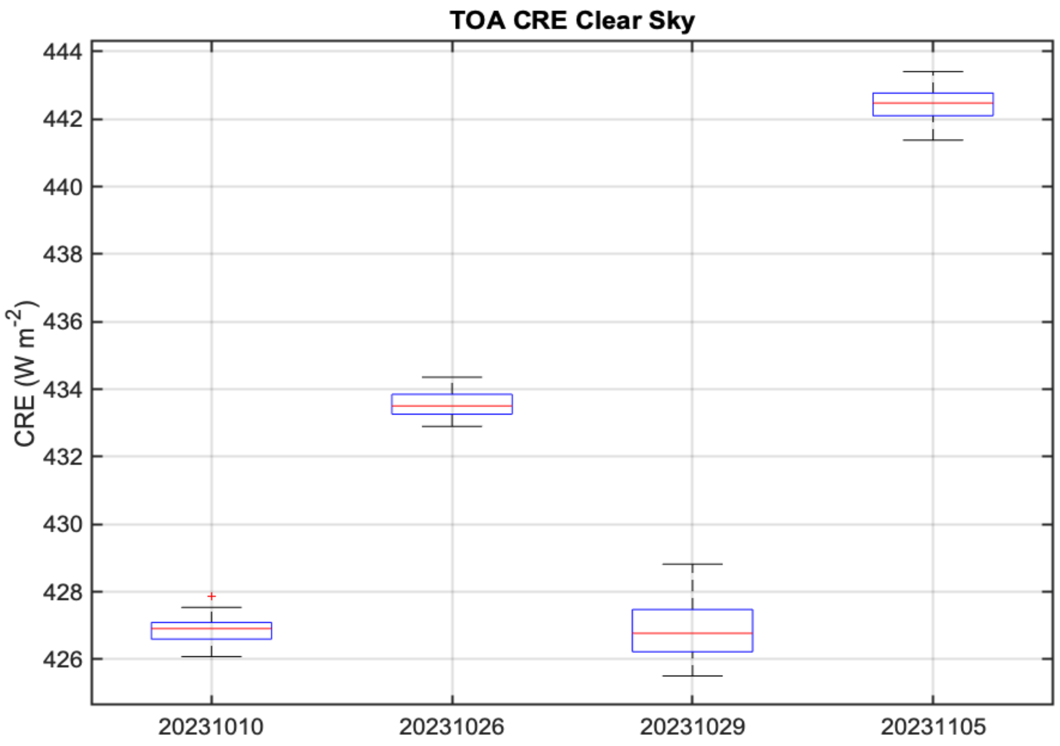
- Clouds
  - Fraction (ICA), optical depth, phase, particle size, top & base
  - Overlapped clouds allowed
  - Inhomogeneity : gamma distribution
  - shape param. ν = (τ/σ)2

- Aerosols
  - Column optical depth (@0.63μ)
  - Constituent type determines spectral optical properties
  - Scale height assumption for vertical profile

Three different scenarios: CLEAR SKY, LOW and HIGH CLOUDS

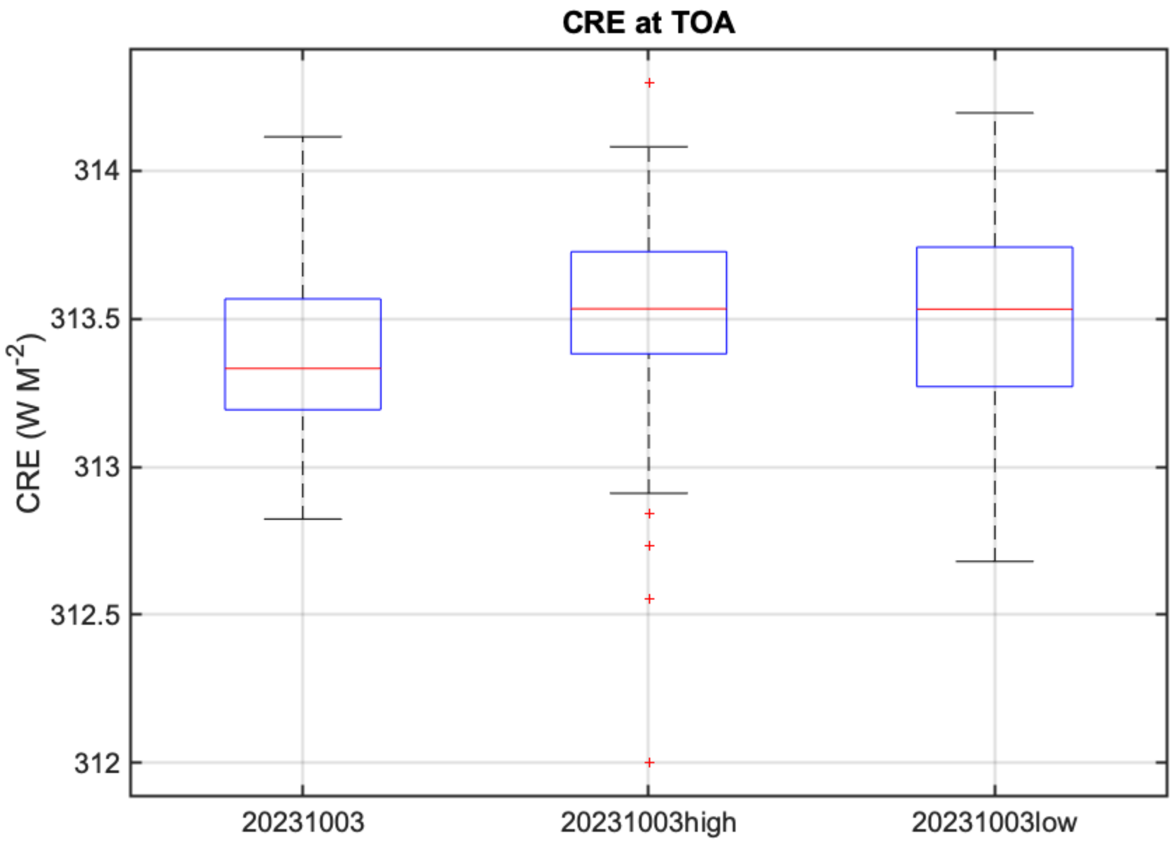
CLEAR SKY

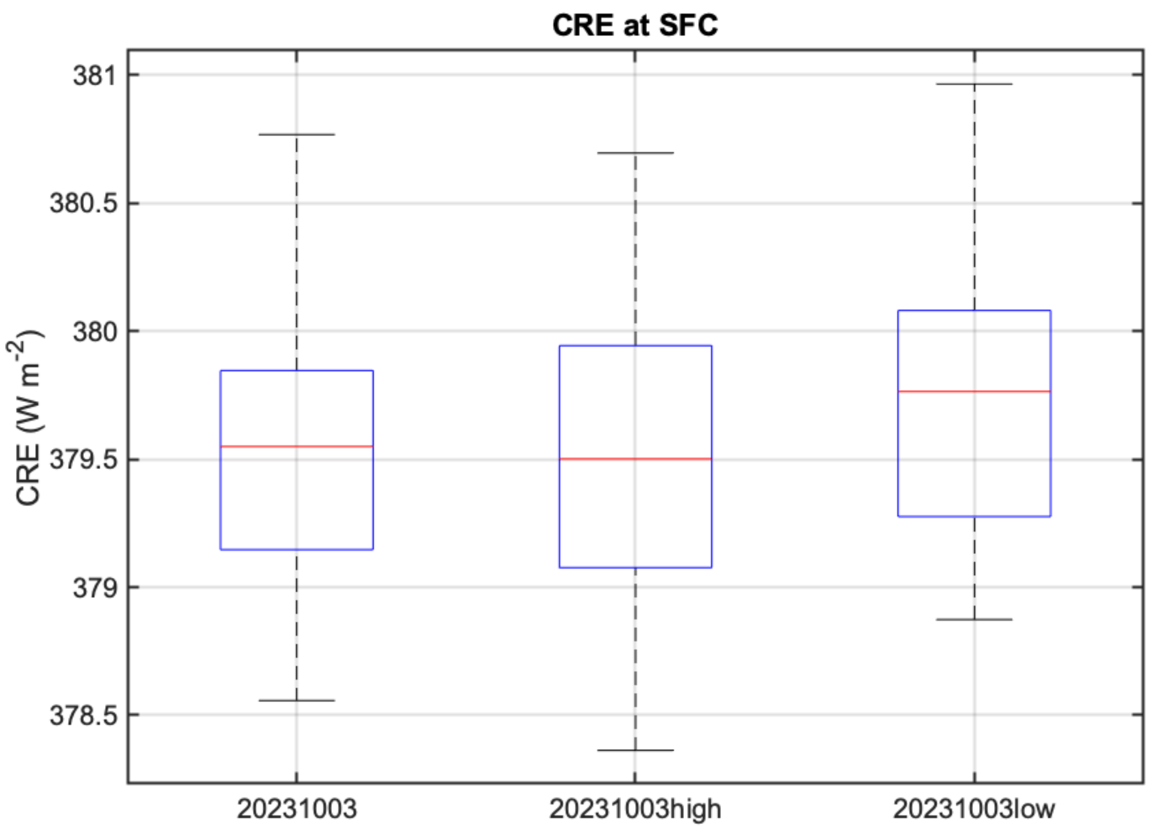




Three different scenarios: CLEAR SKY, LOW and HIGH CLOUDS

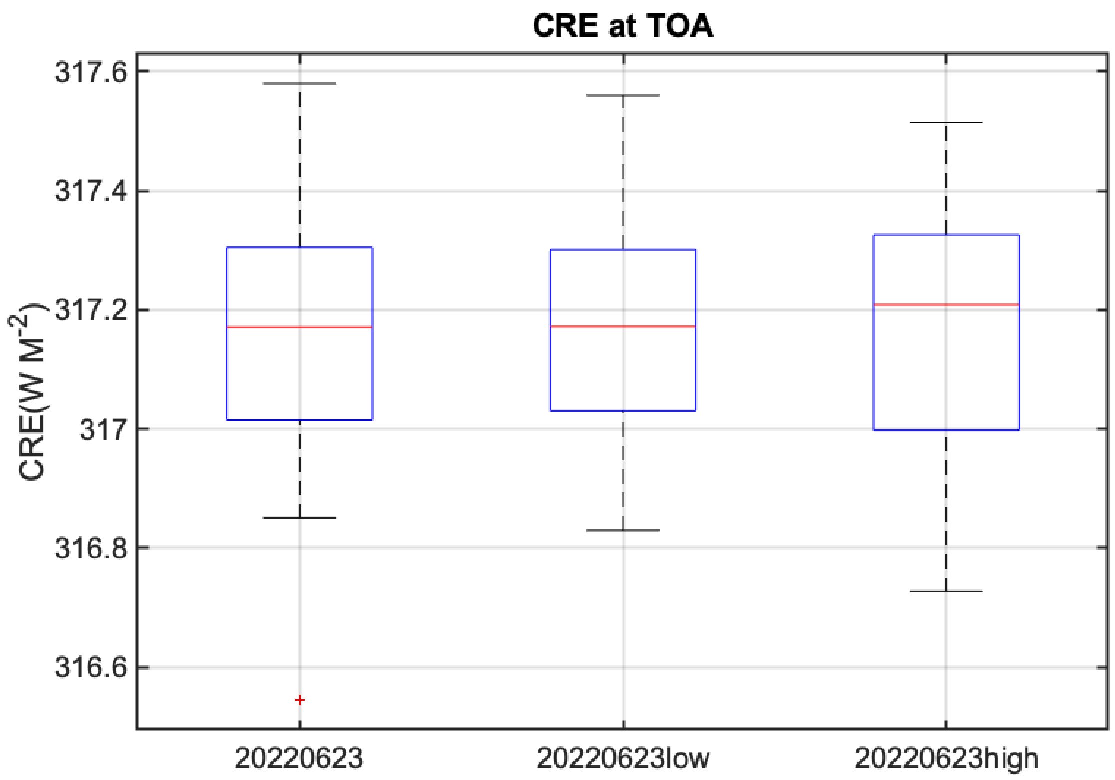
LOW LIQUID CLOUD (TOP at 900m)

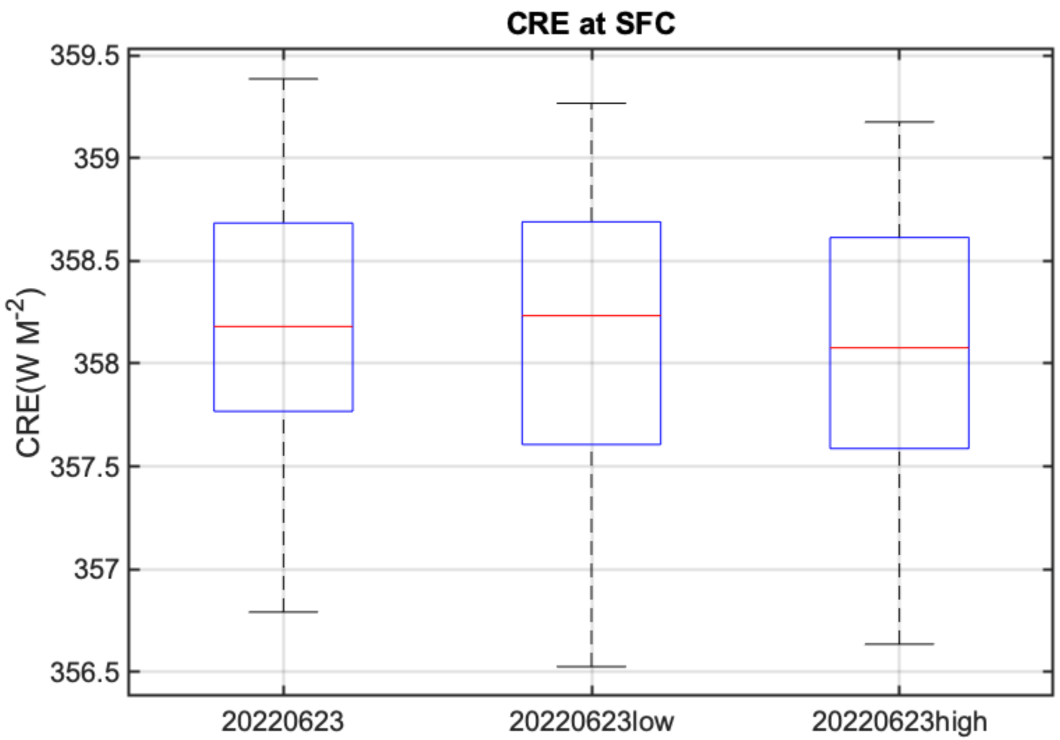




Three different scenarios: CLEAR SKY, LOW and HIGH CLOUDS

CIRRUS CLOUD AT 7200M





Conclusions

- Uncertainty plays a role in assessing the the radiative effects of aerosols, clouds and trace gases
- This is a preliminary results, but, if confirmed, it should be taken into account when the differences in radiative effects are small
- The analysis will continue on more cases

	Clear Sky	Low Clouds	High Clouds
TOA	1-1.5Wm^{-2}	1.5-2Wm^{-2}	1.3Wm^{-2}
SFC	1.5-1.7Wm^{-2}	2Wm^{-2}	1.5-1.8Wm^{-2}

THANKS FOR YOUR ATTENTION