A simulator for the CLARA-A2 cloud climate data record and its application to assess EC-Earth polar cloudiness

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CLARA-A2 simulator

Simulated cloud sensitivity: Optical depth threshold for cloud sensitivity

Simulated cloud sensitivity: Probability of detection

Simulated cloud sensitivity-different outcomes

Arctic cloud climate in the summer

Summary

CLARA-A2 simulator

- CLARA-A2 is a EUMETSAT CM SAF cloud dataset based on 34 years of data from meteorological polar-orbiting satellites (Karlsson et al., 2017).
- The simulated cloud mask more realistically reflects the actual cloud mask performance of the observations than other COSP simulators

Simulated variables

Cloud variable	Categories	day/night
Cloud fraction	total, ice, liquid, low, mid, and high	day/night
Cloud top	height, temperature, pressure	day/night
τ_C	liquid, ice	day only
r_e	liquid, ice	day only
CWP	liquid, ice	day only
CTP-τ_c 2D histograms	liquid, ice	day only

τ_c -threshold for cloud sensitivity

- τ_c-threshold is the cloud thickness where a thin cloud has a 50% chance of being detected.

- The standard is to rely on a global average τ_c-threshold to simulate clouds (τ_c=0.225).
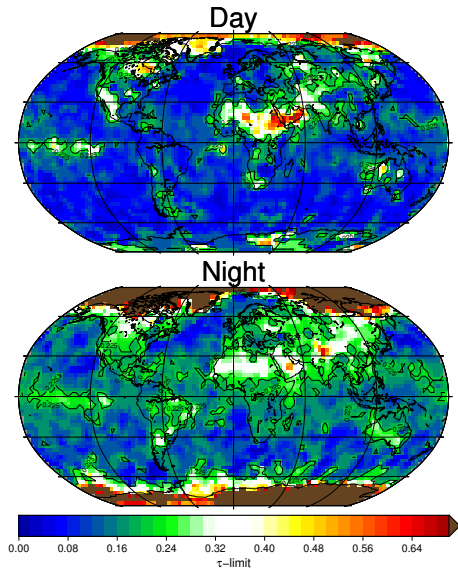
- In some regions this is inappropriate.

Day

Night

Fig. 2 in Eliasson et al. (2020)
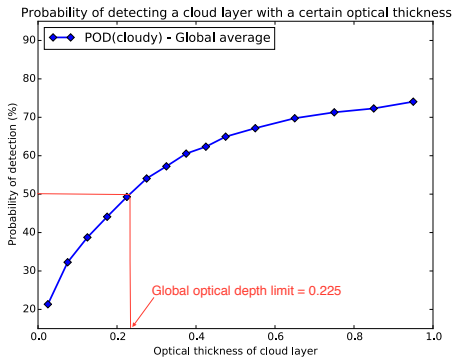
Probability of detection

Probability of detecting a cloud layer with a certain optical thickness

Fig. 6-edited in Karlsson & Håkansson (2018)

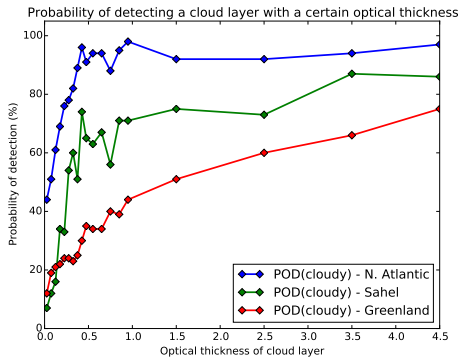Probability of detecting a cloud layer with a certain optical thickness

Fig. 12 in Karlsson & Håkansson (2018)

- An equivalent way to measure the performance of the CLARA-A2 dataset is by POD as a function of optical depth

- The POD generally increases for increasingly thick clouds, and reaches somewhat "asymptotic values" at high optical depths.

- The POD Performance differs depending on geographical location

- The probability of detecting clouds that have τ_c near 0.125 and 0.55 for day and night retrievals

Day

τ0.125   τ0.55

Night

τ0.125   τ0.55

0.0   0.1   0.2   0.3   0.4   0.5   0.6   0.7   0.8   0.9   1.0
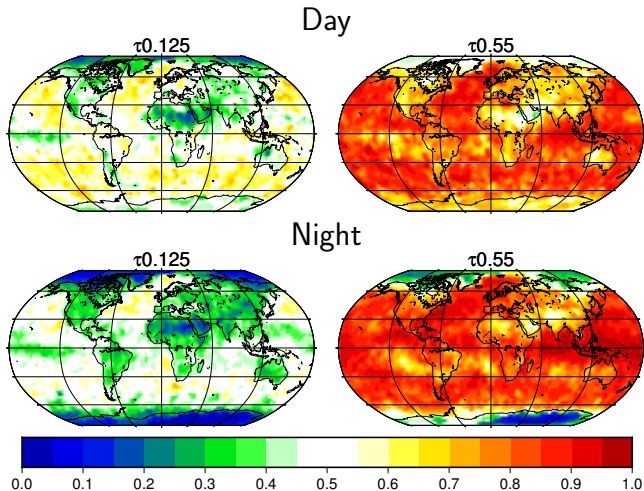
Fig. 3 in Eliasson et al. (2020)

- Easier to detect thicker clouds, but results are regionally variable
- There is a noticeable difference in the performance between day and night

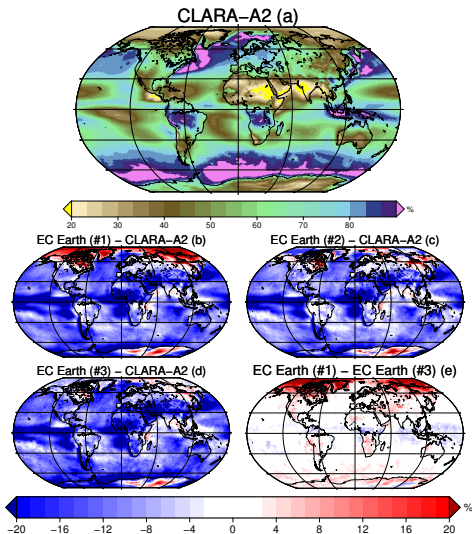# How does a more realistic cloud mask simulation affect model evaluation?

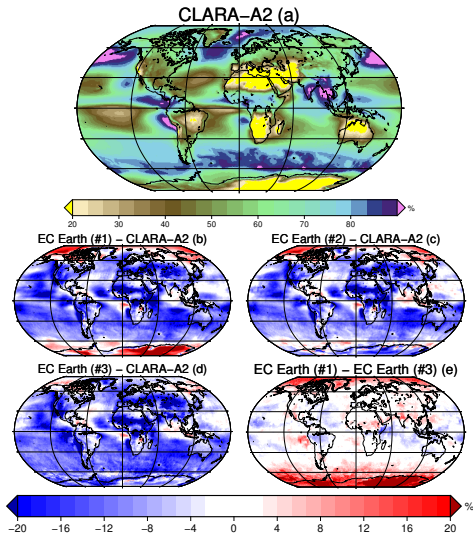**Simulations based on EC Earth minus CLARA-A2: January 1982–2015**

- #1: global τ_c-limit
- #2: spatially variable τ_c-limit
- #3: Using POD

CLARA–A2 (a)

EC Earth (#1) – CLARA–A2 (b)   EC Earth (#2) – CLARA–A2 (c)

EC Earth (#3) – CLARA–A2 (d)   EC Earth (#1) – EC Earth (#3) (e)

Fig. 5 in Eliasson et al. (2020)

How does a more realistic cloud mask simulation affect model evaluation?

Simulations based on EC Earth minus CLARA-A2: July 1982–2015

- #1: global τ_c-limit
- #2: spatially variable τ_c-limit
- #3: Using POD

CLARA–A2 (a)

EC Earth (#1) – CLARA–A2 (b)   EC Earth (#2) – CLARA–A2 (c)

EC Earth (#3) – CLARA–A2 (d)   EC Earth (#1) – EC Earth (#3) (e)

Fig. 6 in Eliasson et al. (2020)

Simulations based on EC Earth minus CLARA-A2/ISCCP-H: JJA 1983–2015

- CLARA simulator uses POD for cloud mask
- ISCCP simulator uses global τ_c-limit
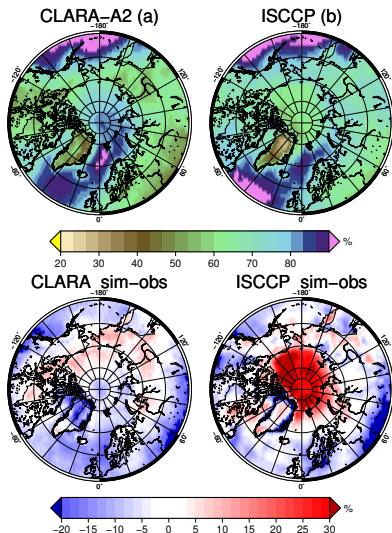- Very different analysis depending on simulator

Fig. 7 in Eliasson et al. (2020)

- Using the validation results from Karlsson & Håkansson (2018), we make a more realistic simulated cloud mask for fairer comparisons
- Is documented fully in Eliasson et al. (2020)
- The simulator code is on Github
- Shortly implementing the simulator into the official COSP distribution

Eliasson, S., Karlsson, K.-G., & Willén, U. (2020). A simulator for the clara-a2 cloud climate data record and its application to assess ec-earth polar cloudiness. *Geoscientific Model Development*, *13*, 297–314.

Karlsson, K.-G., Anttila, K., Trentmann, J., Stengel, M., Meirink, J.-F., Devasthale, A., Hanschmann, T., Kothe, S., Jääskeläinen, E., Sedlar, J., Benas, N., van Zadelhoff, G. J., Schlundt, C., Stein, D., Finkensieper, S., Håkansson, N., & Hollmann, R. (2017). CLARA-A2: the second edition of the CM SAF cloud and radiation data record from 34 years of global AVHRR data, . *17*, 5809–5828.

Karlsson, K.-G., & Håkansson, N. (2018). Characterization of AVHRR global cloud detection sensitivity based on CALIPSO-CALIOP cloud optical thickness information: demonstration of results based on the CM SAF CLARA-A2 climate data record, . *11*, 633–649.