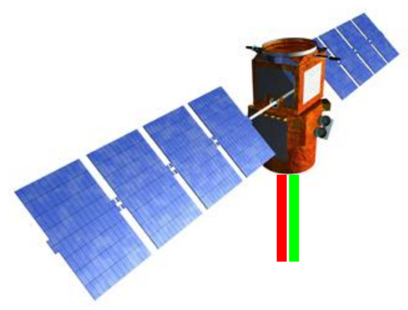

On the Development of Long-term Climate Benchmarks from Satellite Lidars

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Questions

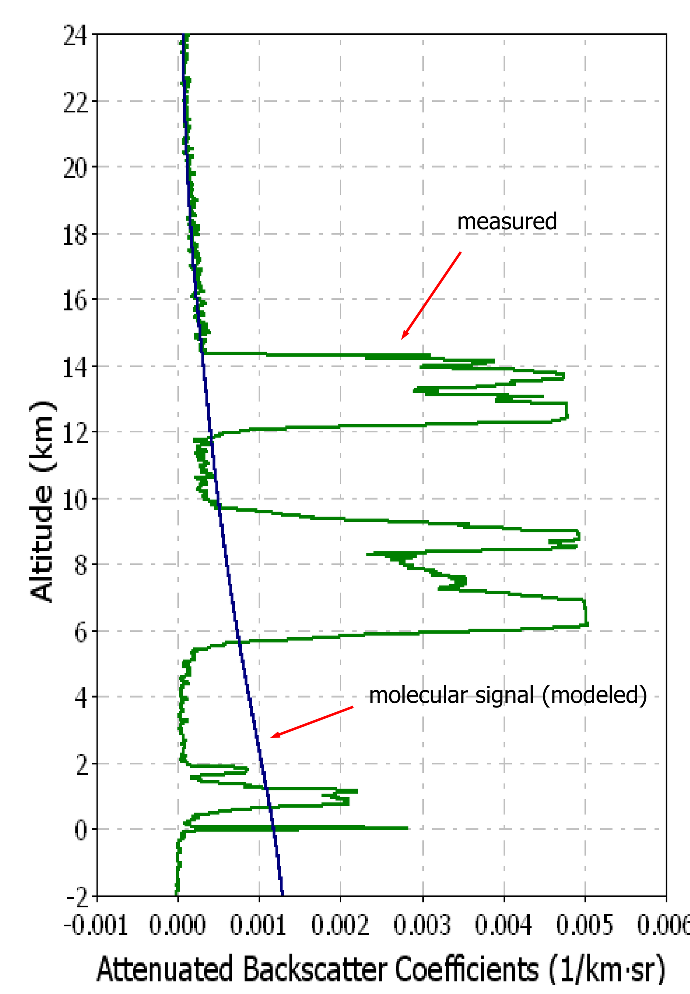
- **“SI Traceability” for lidar: What does it mean? Is it desirable?**
- **Development of multi-decade lidar Climate Data Records:**
  - Requirements? Approaches?

There has been a focus on “SI Traceability” to improve passive observations for climate. Can we (should we) be more rigorous in how we produce or process satellite lidar data?

Which parameters derived from lidar are suitable/desired for ECVs?

Directly measured:
Cloud Occurrence
Cloud Top Altitude (geometric)
Aerosol layer height
Cloud phase

Retrieved:
Cloud optical depth
Aerosol optical depth
Aerosol extinction profile



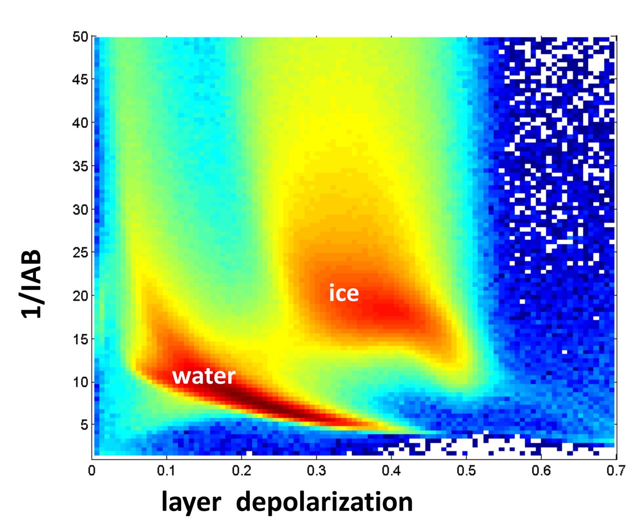
“SI Traceability”: Can/should current lidar methodology be improved?

Calibration uncertainties of passive sensors delay the detection of climate trends by decades relative to a perfect instrument.

Lidar cloud altitude is not a retrieval but *measured* from time-of-flight of the laser pulse.

Altitude measurements are largely independent of radiometric calibration, and stable on the order of meters (Winker et al. 2017).

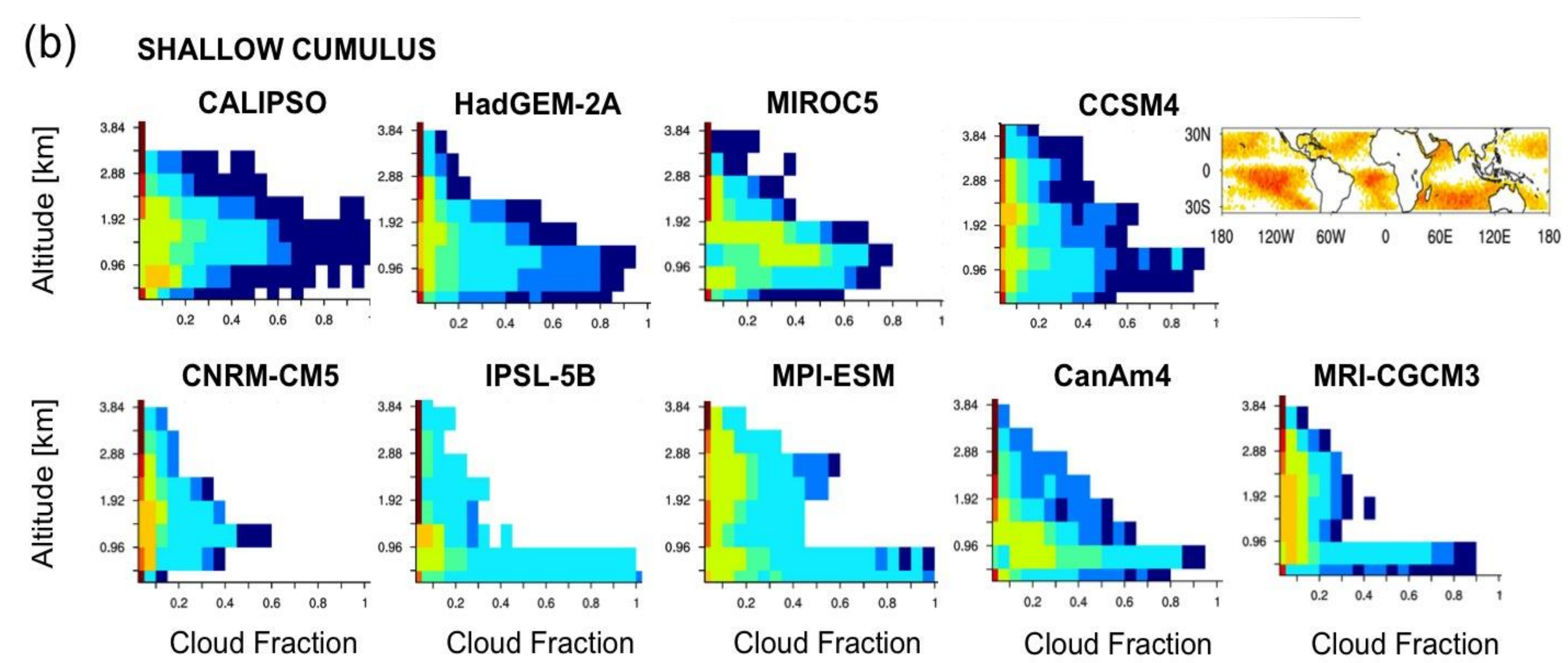
Lidar *retrievals* depend on radiometric calibration, performed via normalization of signal profile to molecular atmosphere.



Motivation

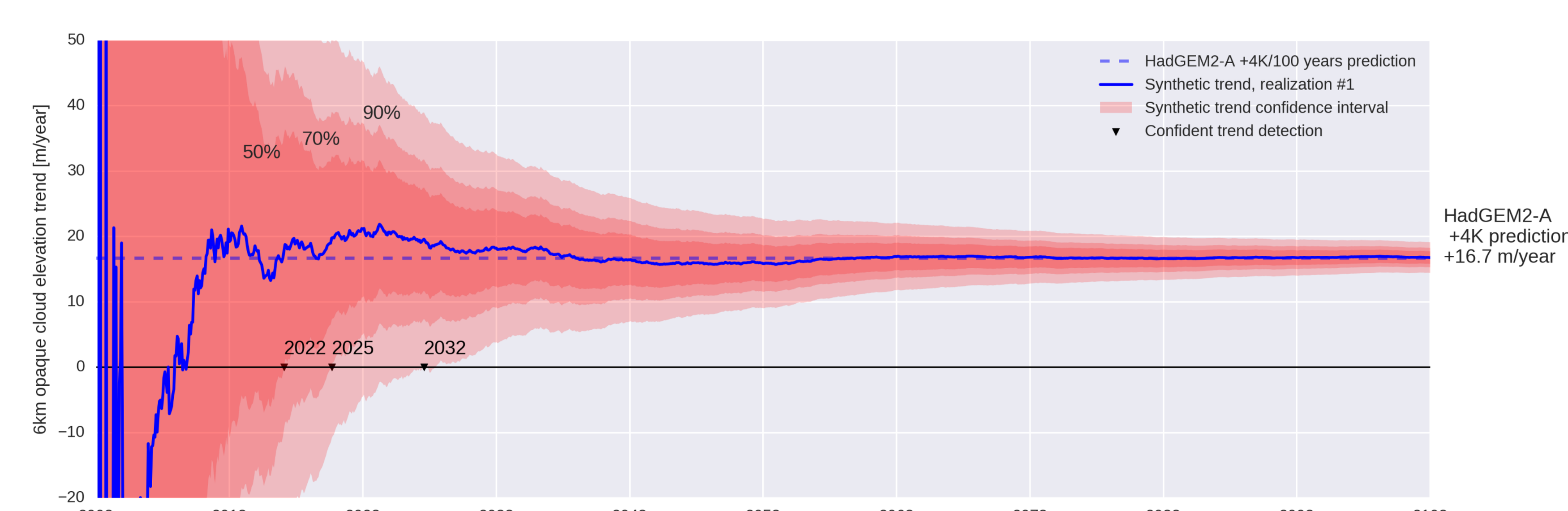
Cloud amount and vertical distribution will change as the climate warms:
- High clouds get higher
- Anvil extent may increase, or decrease
- Low clouds may get shallower, or deeper

These changes, which impact TOA LW and SW radiation, must be accurately monitored. CALIPSO data (Chepfer et al. 2008) has been heavily used by the CFMIP community to evaluate the realism of clouds simulated in climate models



(Nam et al. 2012)

Lidar provides accurate measurements of cloud height, but multi-decade records are needed to separate forced changes from natural variability (Chepfer et al. 2014)



Uncertainty in high cloud altitude trend as a function of the length of the observational record. Based on CALIPSO observations simulated by the HadGEM-2 model. Shading shows 50%, 70%, and 90% confidence envelopes (Winker et al. Surv Geophys 2017).

Multi-Decade Records

CALIPSO (Winker et al. 2010) has now acquired a 16-year record. Stitching the CALIOP record to those from **Aeolus (2018)** and the upcoming **EarthCARE/ATLID (2024),** and **AOS/Clio (2029)** missions requires accounting for instrument differences, including:

- Wavelength (532 vs. 355)
- Instrument sensitivity
- Vertical resolution
- Receiver FOV
- View angle

Questions:

- An initial look at some of these issues was presented in Reverdy et al (2015)
- What steps should be taken toward the development of long-term lidar CDRs?
- What is needed to produce consistent CDRs from current and planned satellite lidars?
- How do we verify consistency of a stitched lidar dataset?
- Should formal processes be established?
- Establish guidelines for better consistency between future lidar instruments?

References:

Chepfer et al. 2008: Use of CALIPSO lidar observations to evaluate the cloudiness simulated by a climate model. GRL, doi:10.1029/2008GL034207

Chepfer et al. 2014: Where and when will we observe cloud changes due to climate warming?. GRL., doi:10.1002/2014GL061792

Nam et al. 2012: The ‘too few, too bright’ tropical low-cloud problem in CMIP5 models. GRL, doi:10.1029/2012GL053421

Reverdy et al. 2015: An EarthCARE/ATLID simulator to evaluate cloud description in climate models. JGR doi:10.1002/2015JD023919

Winker et al. 2010: The CALIPSO Mission: A Global 3D View Of Aerosols And Clouds. BAMS, doi:10.1175/2010BAMS3009.1

Winker et al. 2017: Observational Constraints on Cloud Feedbacks: The Role of Active Satellite Sensors. Surv Geophys doi:10.1007/s10712-017-9452-0