

Satellite remote sensing of cloud base updraft for marine stratocumulus

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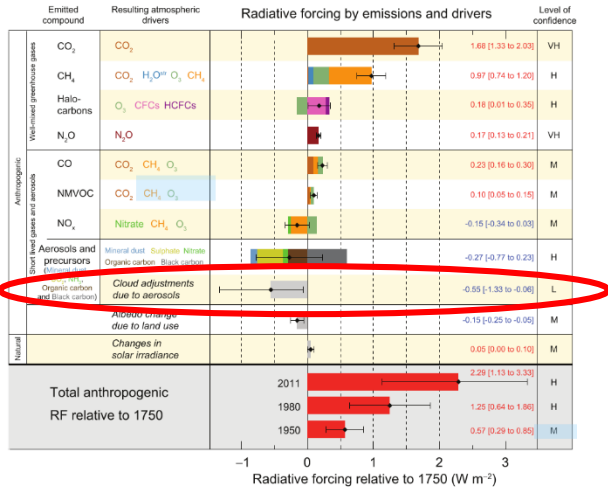
² Institute of Earth Sciences, The Hebrew University of
Jerusalem, Jerusalem, 91904, Israel.





Why cloud base updraft?

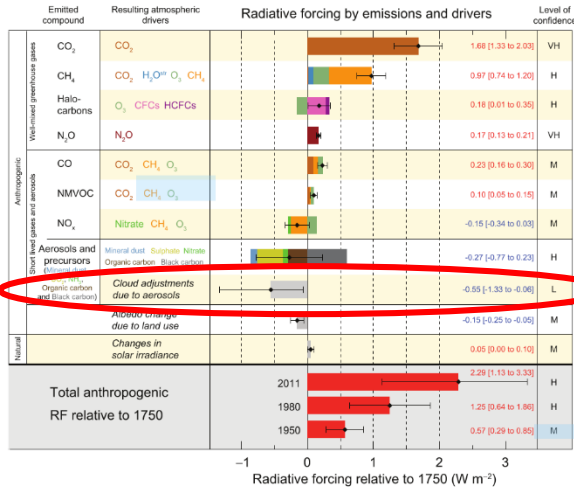
Motivation • Methods • Results • Conclusions



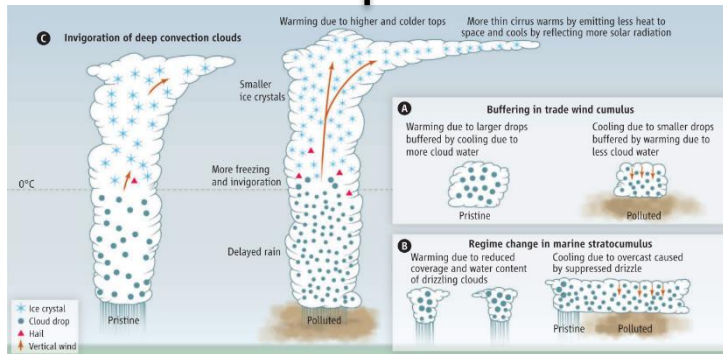
IPCC, 2013

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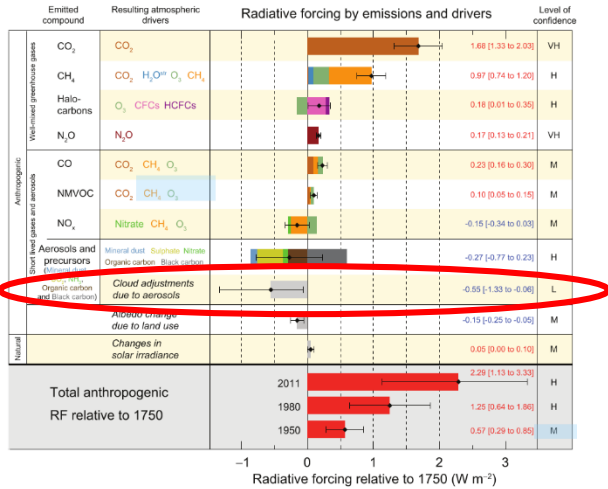
IPCC, 2013



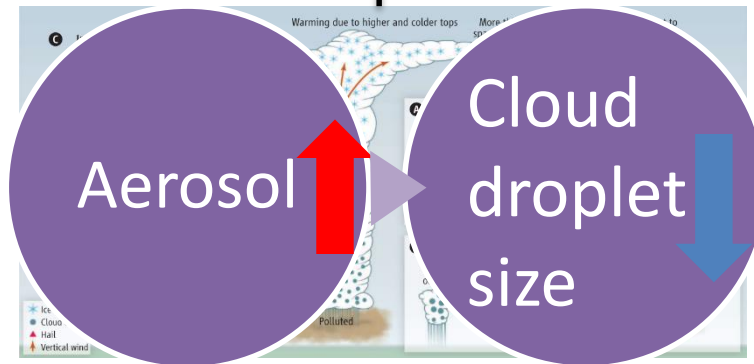
Rosenfeld et al, 2014

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IPCC, 2013



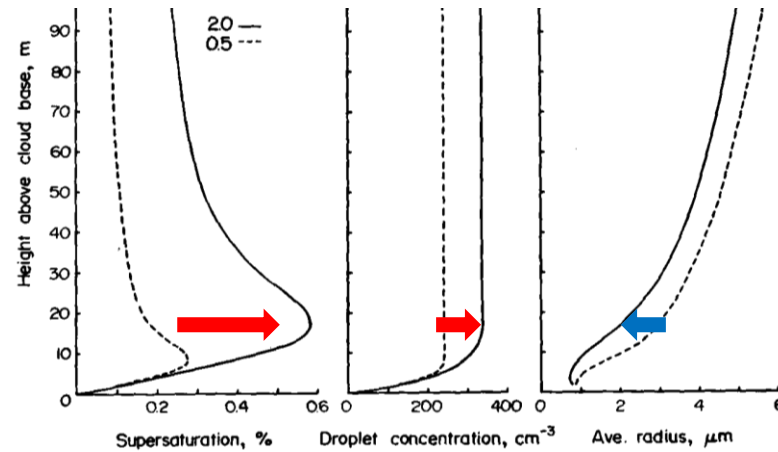
Rosenfeld et al, 2014

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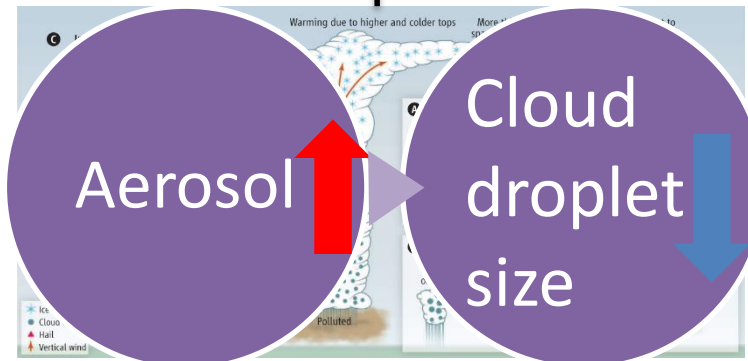
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Category	Emitted compound	Resulting atmospheric drivers	Radiative forcing by emissions and drivers	Level of confidence
Well-mixed greenhouse gases	CO ₂	CO ₂	1.66 [1.33 to 2.03]	VH
	CH ₄	CO ₂ , H ₂ O ⁺ , O ₃ , CH ₄	0.97 [0.74 to 1.20]	H
	Halo-carbons	O ₃ , CFCs, HCFCs	0.18 [0.01 to 0.35]	H
	N ₂ O	N ₂ O	0.17 [0.13 to 0.21]	VH
Anthropogenic aerosols and precursors	CO	CO ₂ , CH ₄ , O ₃	0.23 [0.16 to 0.30]	M
	NMVOC	CO ₂ , CH ₄ , O ₃	0.10 [0.05 to 0.15]	M
	NO _x	Nitrate, CH ₄ , O ₃	-0.15 [-0.34 to 0.03]	M
Cloud feedbacks and aerosols	Aerosols and precursors	Mineral dust, Sulfate, Nitrate, Organic carbon, Black carbon	-0.27 [-0.77 to 0.23]	H
	Cloud adjustments due to aerosols	Cloud adjustments due to aerosols	-0.55 [-1.33 to -0.06]	L
Natural	Absorber change due to land use	Absorber change due to land use	-0.15 [-0.25 to -0.05]	M
	Changes in solar irradiance	Changes in solar irradiance	0.05 [0.00 to 0.10]	M
Total anthropogenic RF relative to 1750			2011: 2.29 [1.13 to 3.33] 1980: 1.25 [0.64 to 1.86] 1950: 0.57 [0.29 to 0.85]	H H M

IPCC, 2013



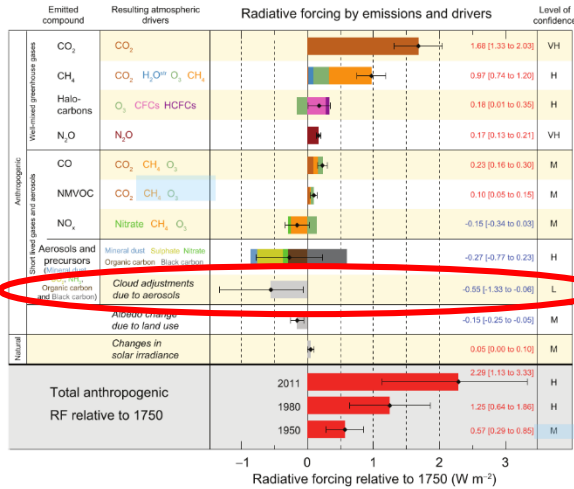
Rogers and Yau, 1988



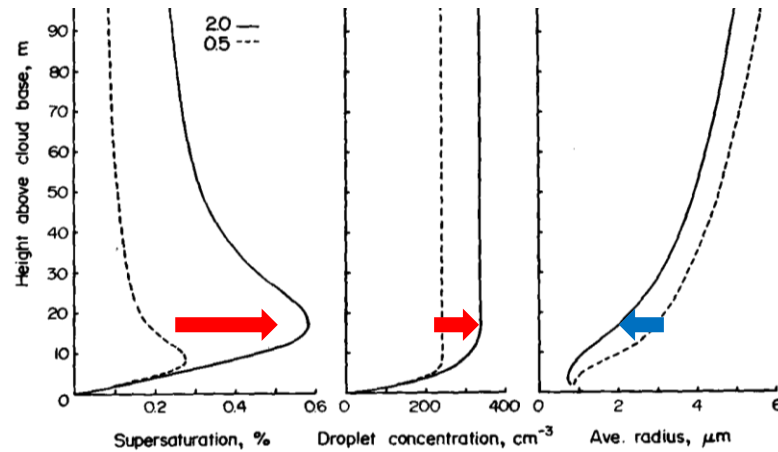
Rosenfeld et al, 2014

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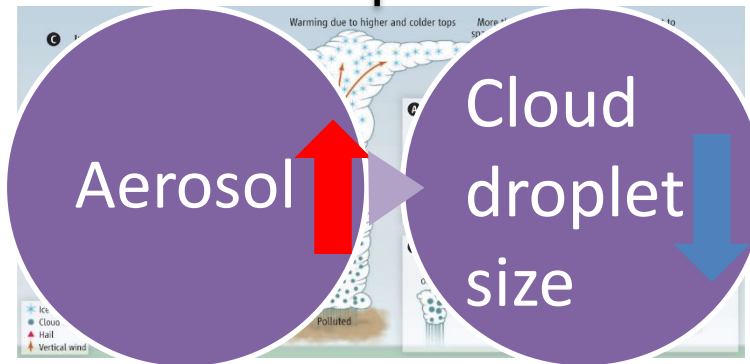
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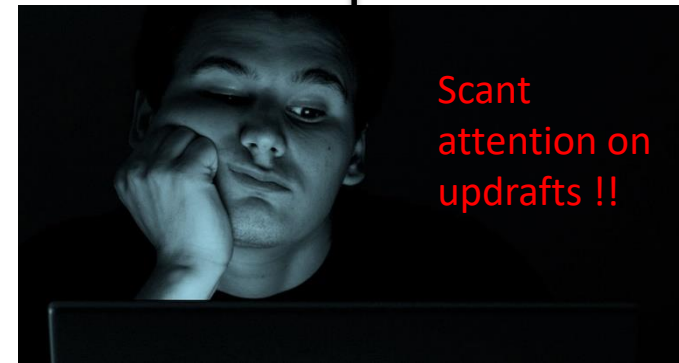
IPCC, 2013



Rogers and Yau, 1988



Rosenfeld et al, 2014





Why cloud base updraft?

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“Are atmospheric updrafts a key to unlocking climate forcing and sensitivity ?”

-----by Leo Donner et al., 2016

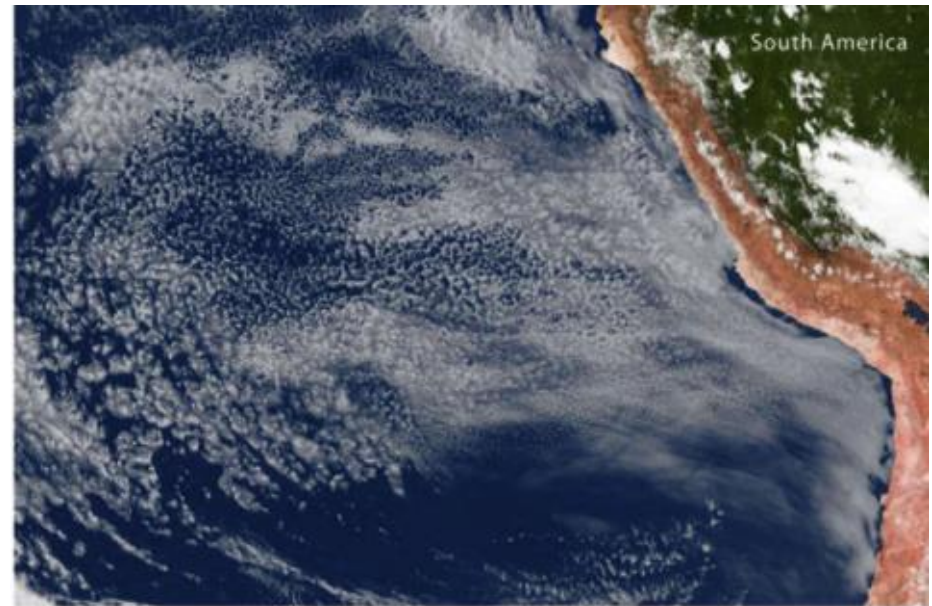


Why marine stratocumulus?

Motivation • Methods • Results • Conclusions

Most **dominant** cloud type by area covered

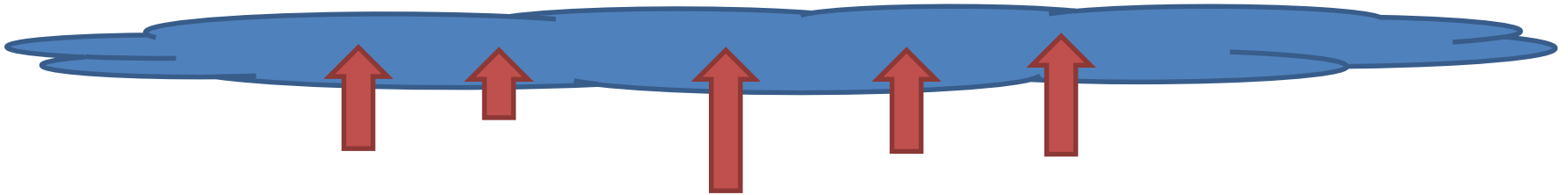
Low clouds: **strong** negative net radiative effect





How to measure cloud base updrafts of stratocumulus from space?

Motivation • **Methods** • Results • Conclusions





Convective nature of stratocumulus

Motivation • **Methods** • Results • Conclusions

Stratocumulus



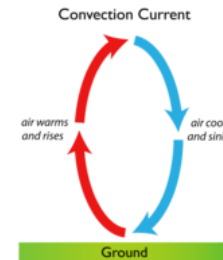
“Layer”



“Heap”



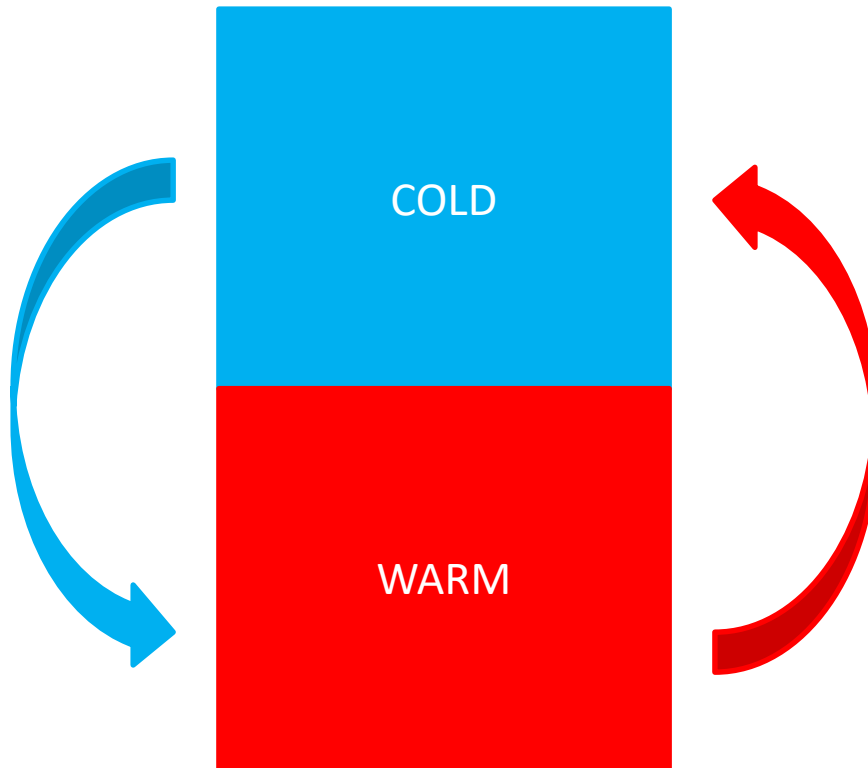
R Wood, 2012





Cloud top radiative cooling (CTRC) drives updrafts

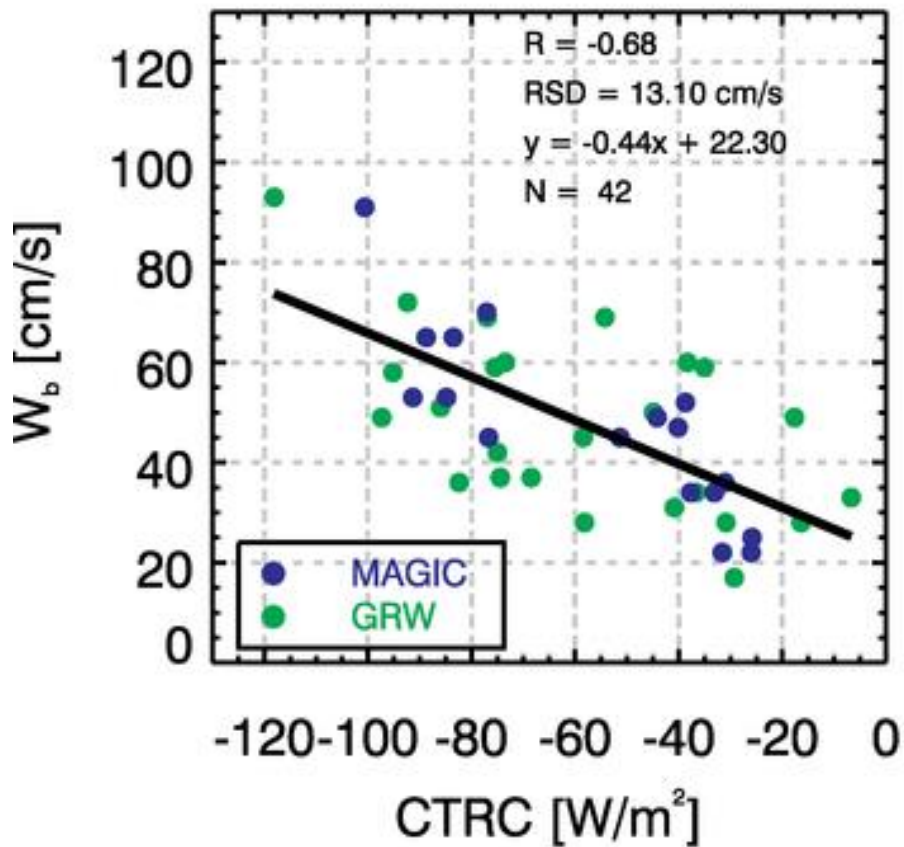
Motivation • **Methods** • Results • Conclusions





W_b versus CTRC

Motivation • **Methods** • Results • Conclusions



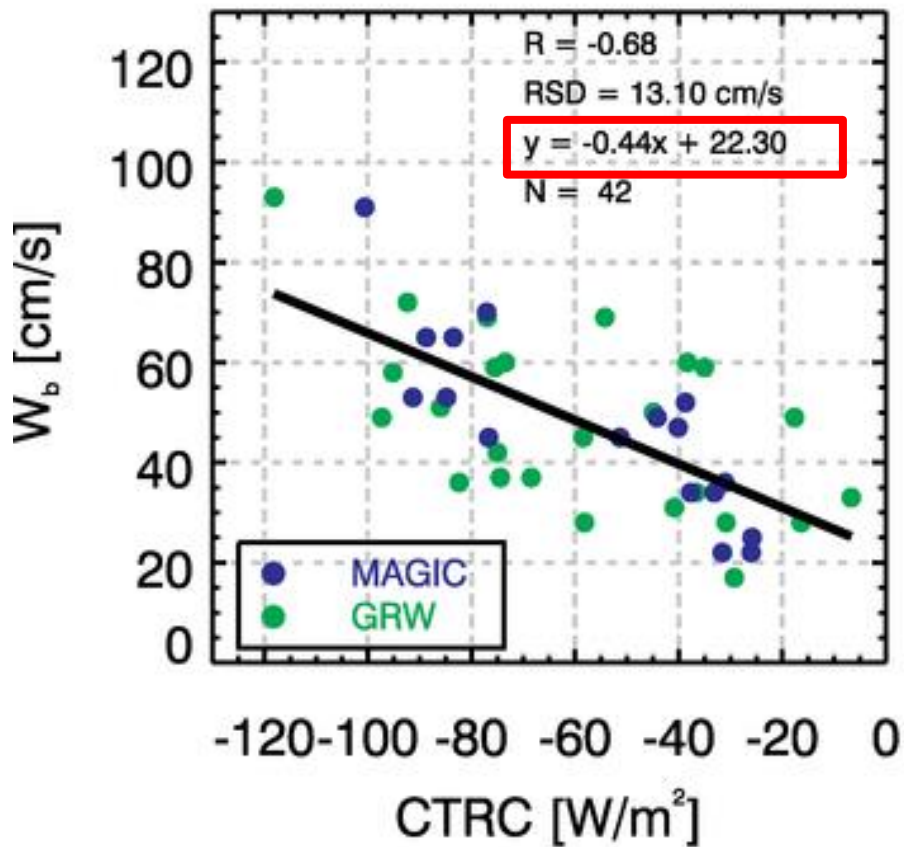
W_b – Cloud base updrafts

CTRC – Cloud Top Radiative Cooling



W_b versus CTRC

Motivation • **Methods** • Results • Conclusions



W_b – Cloud base updrafts

CTRC – Cloud Top Radiative Cooling



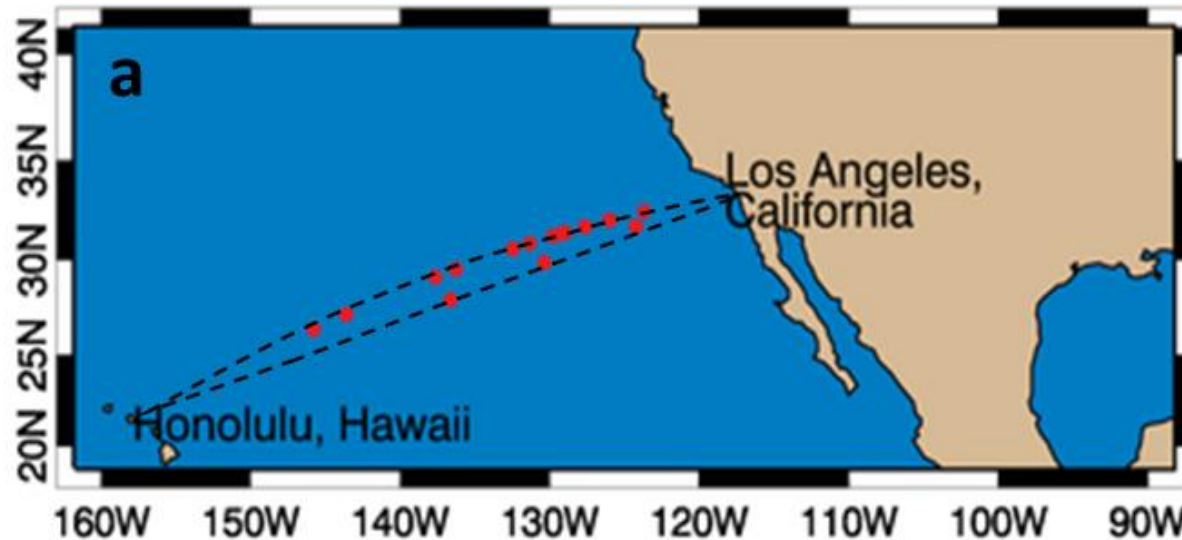
Study region

Motivation • **Methods** • Results • Conclusions



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Science



MAGIC: Marine ARM GPCI Investigations of Clouds



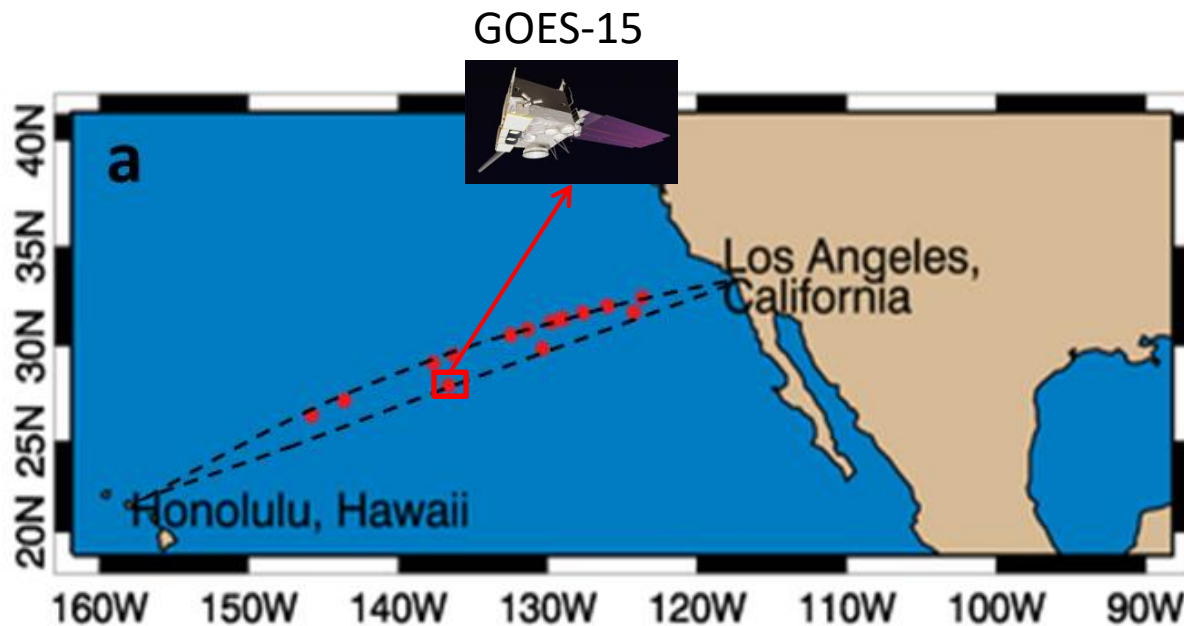
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GOES-15

Motivation • **Methods** • Results • Conclusions

- 15th Geostationary Operational Environmental Satellite: GOES-15

GOES Imager Band	Name	Central Wavelength (μm)	Resolution (km)
1	Visible	0.63	1
2	Shortwave Infrared	3.9	4
3	Water vapor	6.48	4
4	Infrared	10.7	4
6	Split window	13.3	4



GOES-15

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Cloud optical depth

Droplet effective radius

Cloud top temperature

Cloud phase



Calculating CTRC

Motivation • **Methods** • Results • Conclusions

Date source

GOES-15 satellite:

- Visible; 0.63 μm
- SW Infrared; 3.9 μm
- Infrared; 10.9 μm
- Split-window channel; 13.3 μm

ECMWF reanalysis

VISST
(Minnis et al, 2002)

Variables

- Cloud optical depth
- Cloud droplet effective radius
- Cloud top temperature/height
- Cloud phase

- Sounding

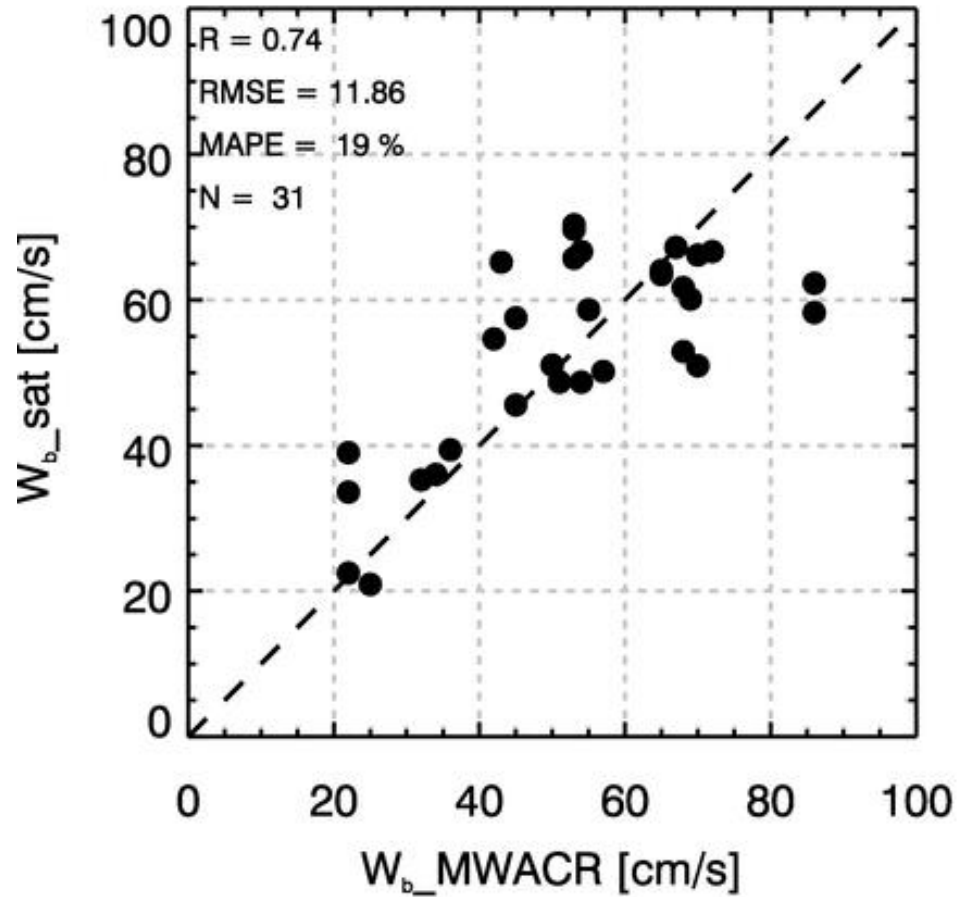
SBDART
(Ricchiazzi et al, 1998)

CTRC



Validation results

Motivation • Methods • **Results** • Conclusions



Zheng et al., 2017, in prep



Conclusions

Motivation • Methods • **Results** • Conclusions

- More attentions needed for updrafts observation.
- First study demonstrating the possibility of retrieving updrafts of marine stratocumulus from space.
- This, in combination with CDNC, allows for the satellite retrieval of **CCN concentration** for marine stratocumulus.

THANK YOU!