The role of upper tropospheric cloud systems in climate : building observational metric for Process Evaluation Studies

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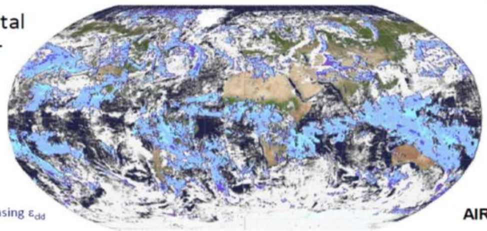
Importance of Upper Tropospheric Clouds

~40% of total cloud cover



play a vital role in climate system by

- modulating Earth's energy budget & upper tropospheric heat transport

They often form mesoscale systems extending over several hundred kilometres.
Cirrus form as outflow of convective / frontal systems or in situ by large-scale forcing

What is the role of cirrus in regulating the Earth's climate & hydrological sensitivities?

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Process Evaluation Study on Upper Tropospheric Clouds & Convection

Motivation: ***understanding feedback of upper tropospheric clouds***

focus on

1) tropical convective systems

explore relation between convection, cirrus anvils & radiative heating, provide obs. based metrics to evaluate detrainment processes in models

2) cirrus originating from large-scale forcing

Resources:

- ***Observations of cloud systems & atmospheric environment***
- ***Including atmospheric flow: cirrus origin & life cycle***
- ***Simulation of processes at different scales (parcel, CRM, GCM)***
- ***Radiative transfer***

1rst meeting in Nov 2015 in Paris
2 informal meetings in Apr 2016: during IRS (Auckland) & in Paris
next meeting: 2017 (USA)
40 participants

Identification of mesoscale high cloud systems (1)

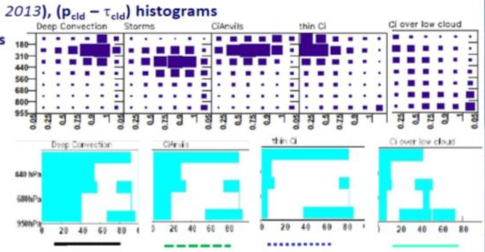
clouds are extended objects, driven by dynamics -> organized systems

Method 1: 'Weather States'

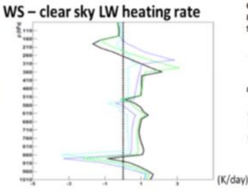
build clusters by occurrence of cloud classes per mesoscale grid (2° - 3°)

-> ISCCP (*e.g. Tselioudis et al. 2013*), **($p_{cld} - \tau_{cld}$) histograms**

-> AIRS ($p_{cld} - \varepsilon_{cld}$) histograms



WS – clear sky LW heating rate



vertical structure from coloc. GEOPROF data CALIPSO-CloudSat

distinct vertical & horizontal structures & radiative effects

observational radiative-convective feedback (e.g. *Lebsock et al. 2010*)
interesting for model evaluation (e.g. *Gehlot & Quaas 2012*) ***but no information of system size***

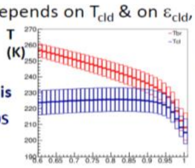
Identification of mesoscale high cloud systems (2)

Method 2: merge adjacent footprints containing cold clouds using $T_B^{IR\ window}$

Machado & Rossow 1993	**(<245 K, Cb < 218 K),**
Yuan & Houze 2010	**(<260 K, Cb from AMSR-E rain rate),**
Fiolleau & Roca 2013	**(< 233 K, Cb from TRMM rain rate) ….**

T_B^{IR} depends on T_{cld} & on ε_{cld}, whereas T_{cld} & ε_{cld} are independent variables:

AIRS analysis 30N-30S



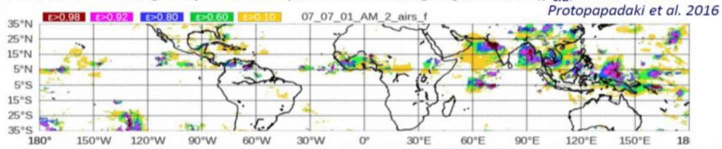
increasing T_B^{IR} threshold includes opaque clouds with $T_{cld} \sim T_B^{IR}$ & clouds with colder T_{cld} & smaller ε_{cld}

215K / 233K / 245K / 260K
0.98 / 0.92 / 0.8 / 0.6

-> *study thick anvils* **life cycle studies**

Method 3: merge adjacent footprints containing high clouds (p_{cld}) from AIRS / IASI

Protopapadaki et al. 2016

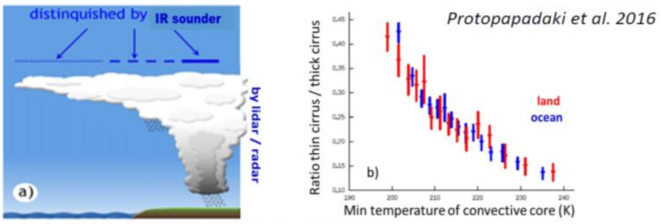


provide observational metrics to probe process understanding

How does the convection affect the heating ?
How do the anvil properties change with convective strength?

Cloud system approach:

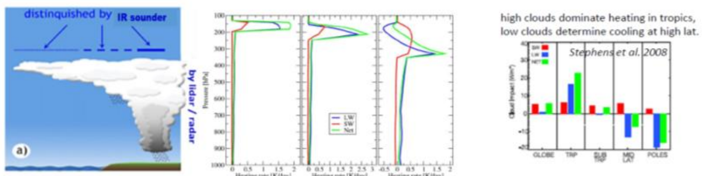
study properties of UT systems (size, thin to thick anvil, etc) as function of their convective strength (proxies: T_{min} / size of convective core)



Behaviour can then be studied by CRM model
or can be used for climate model evaluation

Vertical structure of UT cloud systems and their radiative heating

in tropical convective regions more than 50% of the total heating is contributed by UT heating due to cirrus *(Sohn 1999)*, which then induces a widespread impact on the large-scale tropical atmospheric circulation



Goal: gain a better understanding of relation between convection and heating induced by cirrus anvils

Heating depends on areal coverage, cloud emissivity distribution, vertical structure (multiple layering & microphysics)

determine radiative fluxes & heating rates by categorizing vertical structure wrt cloud emissivity, height, IWP

Evaluation strategies for cirrus systems in climate models

LMDZ cloud system simulator to assess convection / detrainment / microphysics *(see poster Protopapadaki et al.)*