GEWEX Process Evaluation Study on Upper Tropospheric Clouds & Convection

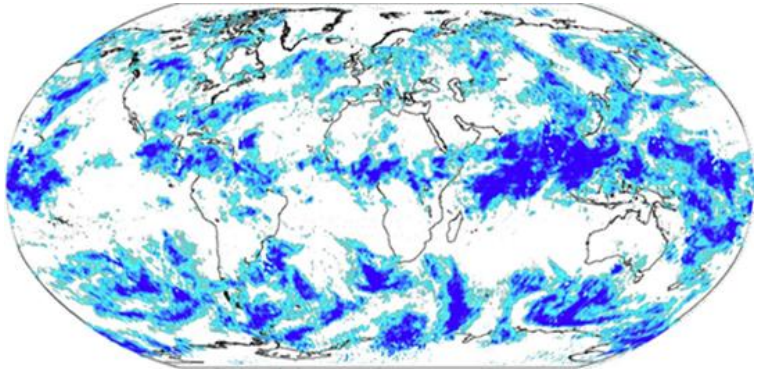
GEWEX UTCC PROES

- ***provide observational metrics to probe process understanding***
- ***advance on understanding feedback of UT clouds***

Coordination: Claudia Stubenrauch & Graeme Stephens

2nd GEWEX UTCC PROES meeting
28-29 Mar 2017, CUNY, New York, USA

Motivation



UT clouds: dark -> light blue, according to decreasing ε_{cld}

UT clouds 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

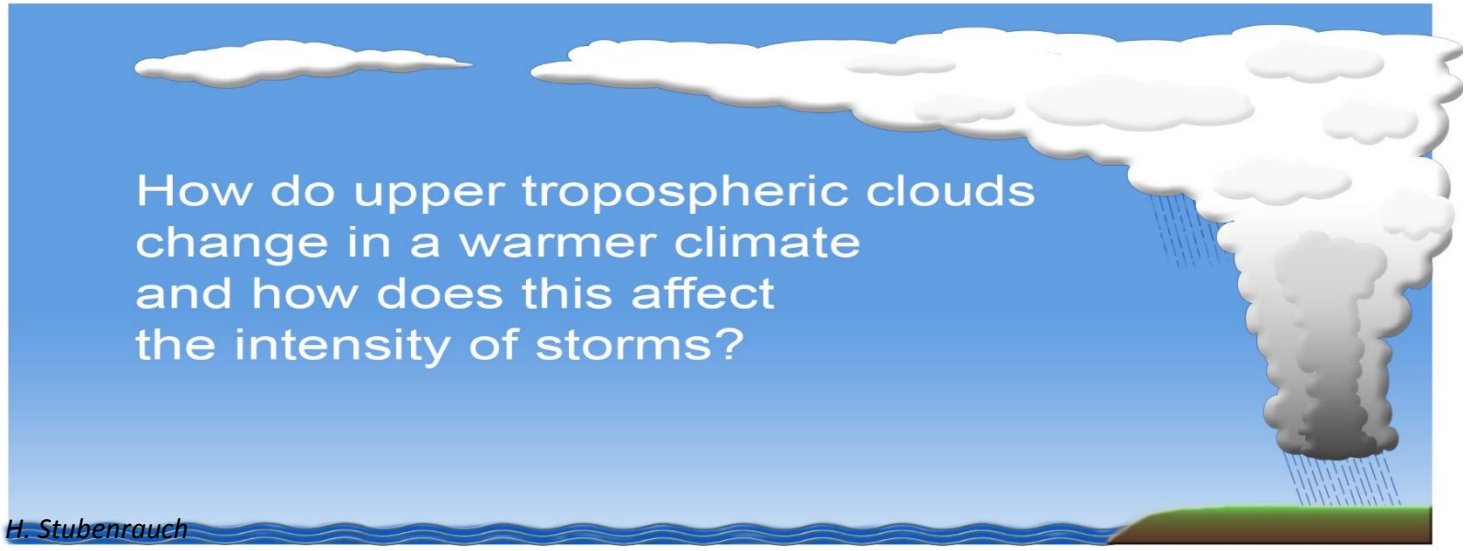
How does convection affect UT clouds & vice versa?
Critical to feedbacks: cirrus radiative heating

How do cirrus change in warming climate? -> rad. heating -> atm. Circulation

What is the role of cirrus in modulating the Earth's climate?

Goal: understand relation between convection, cirrus anvils & rad. heating
provide obs. based metrics to evaluate detrainment processes in models

Actionable Questions



1) How much are anvil properties influenced by convective strength?

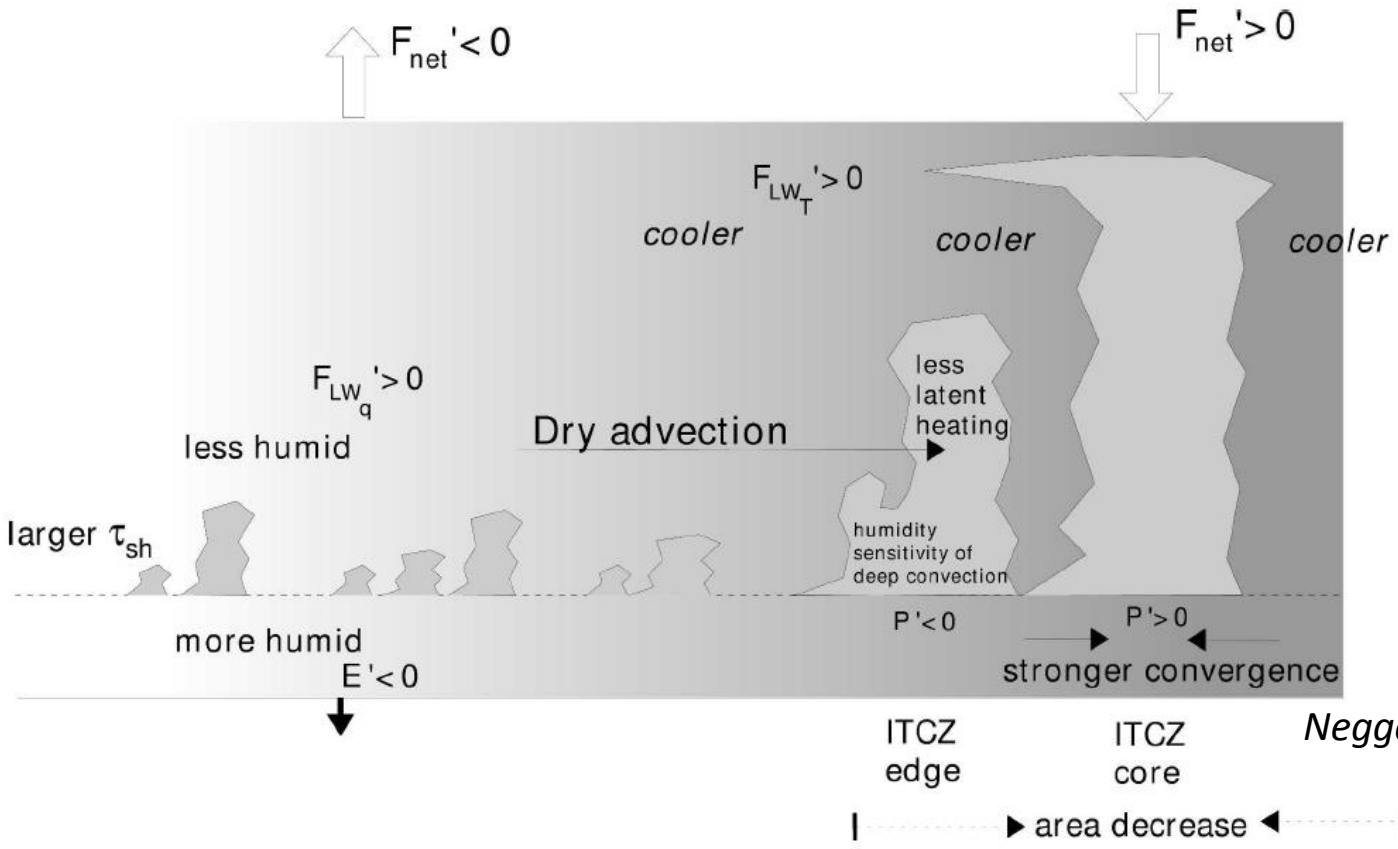
2) What types of cirrus are most responsible for heating the atmosphere and thus influential to climate sensitivity?

- How much of the heating can be traced to convectively generated cirrus ?
- How much of the variability of UT heating is governed by variability in areal coverage, emissivity and microphysics ?

3) How does the heating affect the convection ?

Interconnections: shallow cumulus – deep convection

from Seiji Kato's talk at IRS 2016



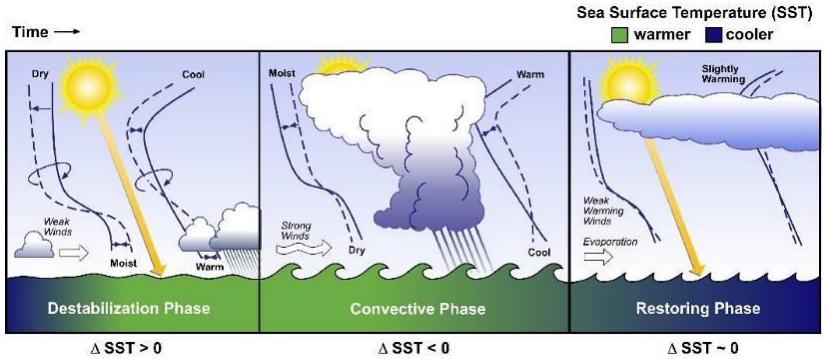
Neggers et al. 2007

More humid boundary layer -> more shallow cumulus
-> dryer free troposphere -> narrower ITCZ
-> stronger precipitation by deep convective clouds

Other feedback hypotheses

➢ **Thermostat** (*Ramanathan & Collins 1991*) : warmer environment creates thicker Ci anvils -> subsequently cooled by more reflective Ci (negative feedback)

➢**Humidistat** (*Stephens et al. 2004, Lebsock et al. 2010*) : self-regulating radiative – convective feedback mechanism in 3 phases :



➢**IRIS effect** (*Lindzen et al. 2001*) : warmer environment -> increase in precip. efficiency -> decrease of anvil area (negative feedback)

➢**Stability IRIS effect** (*Bony et al. 2016*) : warmer environment -> anvils rise

-> increase in static stability-> reduction of convective outflow
enhanced convective aggregation -> increased IRIS effect *(Mauritsen & Stevens 2015)*
including cloud-radiative effects -> narrowing of rainy areas

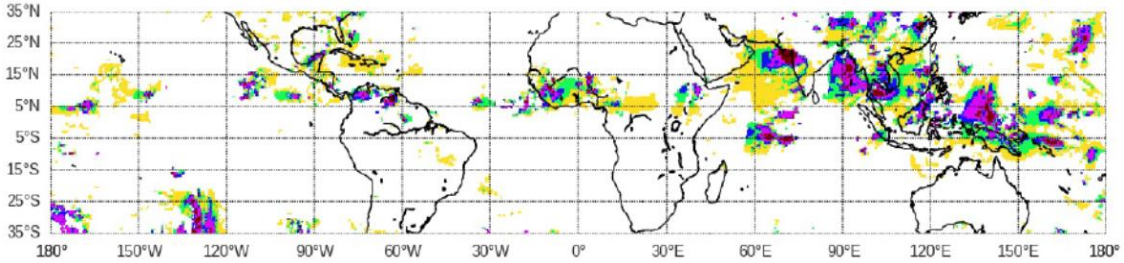
UTCC PROES Strategy

form working group *(meetings: Nov 2015, Apr 2016, Mar 2017)*
links communities from observations, radiative transfer,
transport, process & climate modelling

focus on tropical convective systems *& cirrus originating from large-scale forcing*

- **cloud system approach, anchored on IR sounder data**

horizontal extent / convective cores/cirrus anvil/thin cirrus ***based on p_{cld}, ε_{cld}***



AIRS-CIRS
ε_{cld} > 0.98, 0.92-0.98, 0.8-0.92, 0.6-0.8, 0.6-0.1

- **explore relationships between 'proxies' of convective strength & anvil properties**
- **prepare synergetic data,** incl. vertical dimension & atmosph. environment
- **determine heating rates** of different parts of UT cloud systems
- **investigate how cloud systems behave in CRM studies**

& in GCM simulations *(under different parameterizations of convection/detrainment/microphysics)*

Goals of this meeting

1) present synergetic data & relationships between convection and anvils
(needs proxies to identify convective core, system maturity and convective strength)

Discuss:

2) diagnostics for evaluating modelling at different scales
(CRM resolving convection and GCM using parameterizations)
3) strategies for determining latent / radiative heating rates
4) how to implement heating rates in the analysis of cloud system evolution
5) how to separate cirrus originating from convection and in-situ freezing
….