GEWEX Process Evaluation Study on Upper Tropospheric Clouds & Convection

GEWEX UTCC PROES

Å *provide observational metrics to probe process understanding*

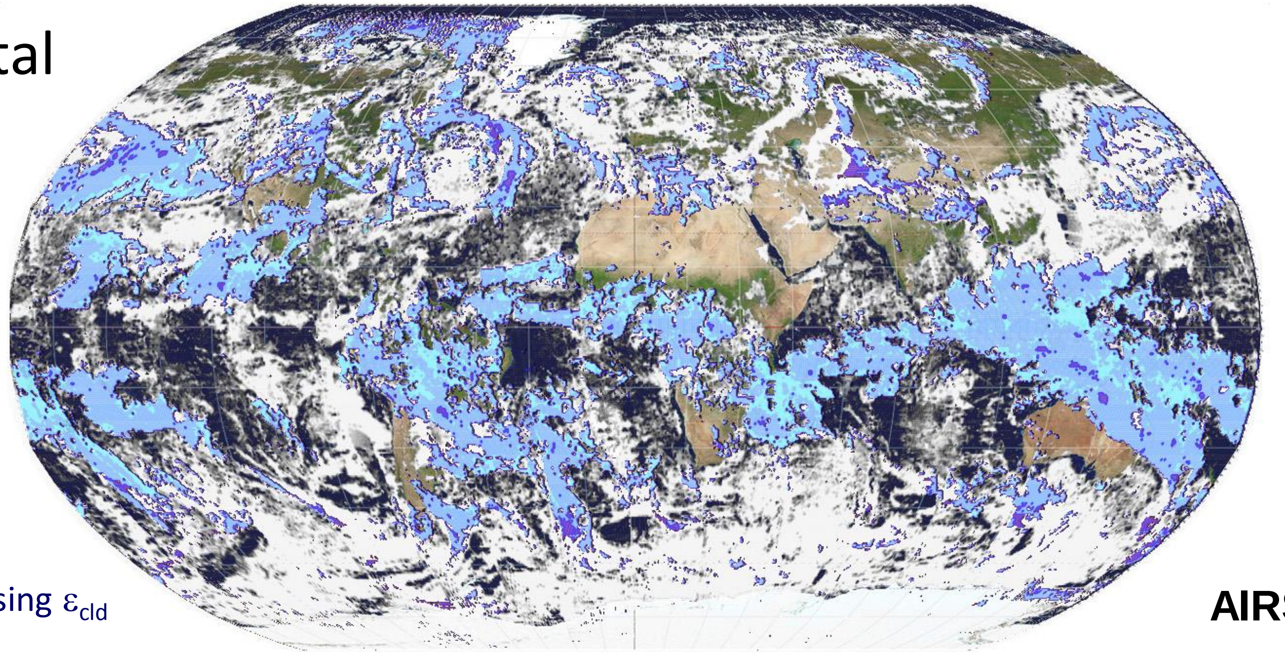
Å *advance understanding on feedback of upper tropospheric clouds*

Coordination: **Claudia Stubenrauch & Graeme Stephens**

UTCC PROES meeting, 29 Apr 2016, Paris, France

Importance of Upper Tropospheric Clouds

~40% of total cloud cover



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

AIRS-LMD

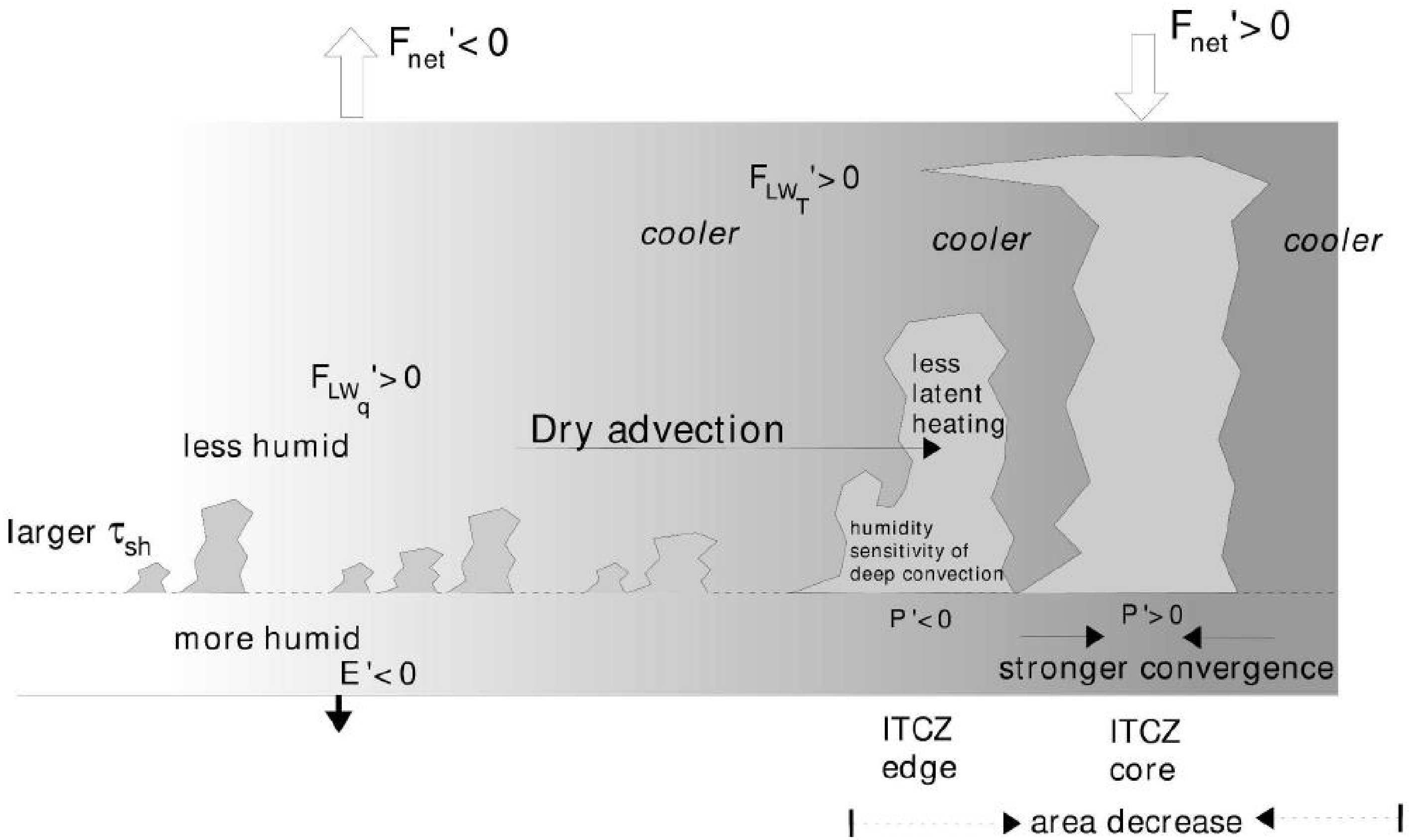
play a vital role in climate system by

- modulating Earth's energy budget & upper tropospheric heat transport
- influencing response of Earth's water cycle to climate forcings

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

Proposed interconnection betw shallow cumulus & deep convection

from Seiji Kato's talk at IRS



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

Neggers et al. 2007 J. Climate

1. GEWEX UTCC PROES meeting

Feedback hypotheses

*V. Ramaswamy, **T. Mauritsen, S. Bony***

Ressources

1) observations: cloud systems and atmospheric environment

*W. B. Rossow, H. Masunaga, D. Bouinol, **R. Roca, G. Sèze, S. Protopapadaki, C.-K. Teo***

2) including the atmospheric flow: Cirrus origin and life cycle

J. Luo, B. Legras, R. Plougonven, A. Podglajen

3) processes and parameterizations (parcel, CRM, GCM)

Small scale process modelling *S. van den Heever*

Large scale development / evaluation of parameterizations (LMDZ, CNRM, ETHZ)

C. Risi, C. Rio, , J.-B. Madeleine, B. Gasparini

4) Radiative transfer

*T. L'Ecuyer ,**C. Stubenrauch***

next day: **Discussion on Synergetic data base**

J. Luo, G. Stephens, G. Sèze, S. Protopapadaki, S. Stubenrauch

interested in cirrus -> anchor data base to AIRS upper tropospheric cloud systems

UTCC PROES Synergies

A-Train (AIRS-CALIPSO-CloudSat-AMSR-E):

- **vertical structure of cloud types (as fct of distance to convective cores)**
- **comparison of proxies for convective strength**

GridSat-ISCCP-Meghatropiques-AIRS-IASI-TRMM :

life cycle of cloud systems

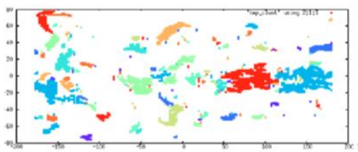
Meteorological reanalyses : mesoscale winds, thermodynamics

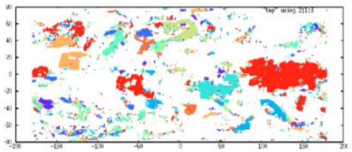
atmosph./cloud properties & Lagrangian transport model
-> cirrus origin & evolution

atmosph./cloud properties & radiative transfer model
-> cirrus heating rates

vertical layering, vertical IWC / De profiles important
parameterization as fct of IWP (e.g. *Feofilov et al. ACP 2015*)

Simulator of high-altitude cloud systems for evaluation of different convection schemes / microphysics in GCMs





GEWEX UTCC PROES discussions at IRS

V. Ramaswamy (GFDL), A. Baran (MetOffice), D. Bouniol (CNRM), R. Roehrig (CNRM), B. J. Sohn (Seoul Univ.), S. Kato (Nasa Langley), H. Okamoto (Kyushu Univ.), M. Wendisch (Univ. Leipzig), S. Kinne (MPI-M), C. Stubenrauch (LMD)

1) parse the thematic question into specific actionable questions

2) see how these can be addressed within CFMIP activities

3) LMDZ tests cloud system simulator to assess convection / detrainment / microphysics schemes

2) make an inventory of variables needed & sources, uncertainties

3) build synergetic data bases to address each of the questions instead of one synergetic data base which includes all information ?

Actionable questions

1) How does the convection affect the heating ?
What types of cirrus are most responsible for heating the atmosphere and thus influential to climate sensitivity?

Å How much of the heating can be traced to convectively generated cirrus ?

Å How much of the variability of UT heating is governed by variability in areal coverage, emissivity and microphysics ?

2) How does the heating affect the convection ?

Data &Variables

1) Vertical profile data:

Vertical structure & heating rates from CALIPSO-CloudSat matched with AIRS cloud pressure & emissivity

- convective intensity, $Q_{rad}(z)$, ε_{cld}, p_{cld}, z_{cldtop}, $z_{cldbase}$, IWC(z), De(z), nb of layers

2) Horizontal structure data:

AIRS cloud systems, environmental state data from reanalyses, surface precipitation from AMSR-E, UTH from AIRS-AMSU, MLS

- cld type, ε_{cld}, p_{cld}, RR, RR_{max}, UTH, stat stability, mass flux, T_{surf}, convergence/divergence ?

3) Horizontal – vertical hybrid data:

AIRS cloud systems, vertical structure & heating rates from CALIPSO-CloudSat, MODIS-CERES cloud objects & heating rates from CERES

4) Time dimension for life cycle analysis:

AIRS cloud systems coupled to MCS's from geostationary TB tracking

Evaluation strategies for cirrus systems in climate models

separate evaluation of cirrus systems originating from convection & large-scale forcing

- **LMDZ: thermodynamical approach (*Hourdin et al. 2013*)**
- **ECHAM-HAM: microphysical scheme accounting for aerosol-cloud interactions (*Kuebbeler et al. 2014*)**

build 'simulator' of high cloud systems

compare horizontal extent & life time of Ci anvils in relation to convective strength, expansion & contraction of tropical convective systems in relation to conv. strength & cirrus heating

include most suitable thermodynamical phase relation & microphysical structure for radiative transfer