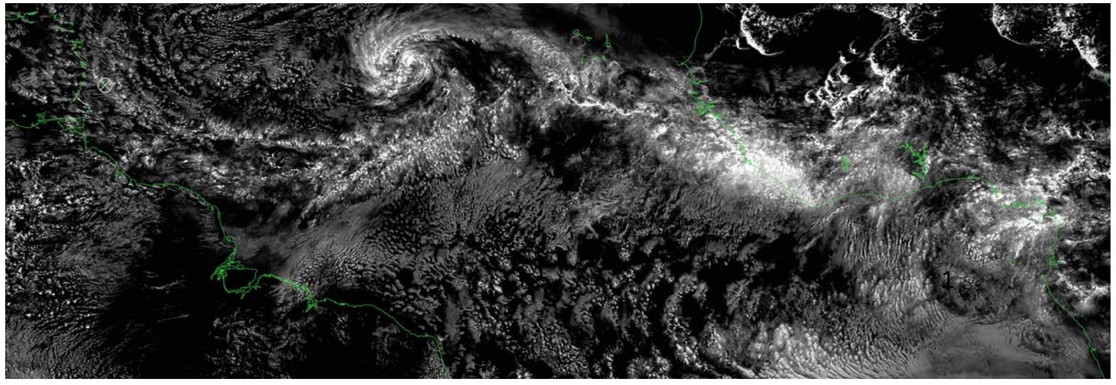
GEWEX Global Atmospheric System Studies (GASS)

Xubin Zeng (Co-Chair, USA), Daniel Klocke (Co-Chair, Germany),
Irina Sandu (ECMWF), Shaocheng Xie (USA),
Ian Boutle (UK), Yongkang Xue (USA)

25 Feb – 1 Mar 2019
GEWEX SSG
Geneva, Switzerland



Highlights - Part I

- Highly successful Pan-GASS Conference in Australia from 26 Feb – 2 Mar 2018
- Four new projects initiated, another is close to being launched
- They are highly related to the top three errors from WGNE Systematic Error Survey Results Summary (2/11/2019, C. Reynolds et al.)

  --- Precipitation diurnal cycle, intensity and frequency
  --- Surface fluxes and temperature diurnal cycle
  --- Cloud microphysics

- Panel members recruited, based on projects
- Streamlining the GASS relationship with PROES (GAP, UTCC)
- Comprehensively revised the GASS projects web site

Understanding and Modelling Atmospheric Processes

The 2nd Pan-GASS meeting sponsored by the ARC Centre of Excellence for Climate System Science

26TH FEBRUARY 2018 - 2ND MARCH 2018, LORNE, VICTORIA, AUSTRALIA

- 200+ abstracts
- 168 accepted
- 160+ registrations
- 10 sessions
- breakout groups
- planery discussions

with the goal to initiate projects

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Future Community Efforts in Understanding and Modeling Atmospheric Processes

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Future Community Efforts in Understanding and Modeling Atmospheric Processes

Xubin Zeng[1,*], Daniel Klocke[2,*], Ben J. Shipway[3], Martin S. Singh[4], Irina Sandu[5], Walter Hannah[6], Peter Bogenschutz[6], Yunyan Zhang[6], Hugh Morrison[7], Michael Pritchard[8], and Catherine Rio[9]

[1] University of Arizona, Tucson, AZ, USA
[2] Hans Ertel Center for Weather Research, Deutscher Wetterdienst, Germany
[3] Met Office, United Kingdom
[4] Monash University, Clayton, Victoria, Australia
[5] European Centre for Medium Range Weather Forecasts, Reading, UK
[6] Lawrence Livermore National Laboratory, Livermore, CA, USA
[7] National Center for Atmospheric Research, Boulder, CO, USA
[8] University of California, Irvine, CA, USA
[9] Centre National de Recherches Météorologiques, CNRS, Toulouse, France

Ahead of Print

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Featured Special Colle

Waves to Weather (W2W)
- JAS, MWR, JHM, WAF

Process-Oriented Model Diagno
- JCLI, JAS

Highlights - Part II

- **Close collaboration with the DOE ARM:**

ARM Technical Director Jim Mather and Zeng attended the GASS and ARM meetings respectively; ARM observations will be used in GASS projects; ARM provides small support for GASS-related meetings, and ARM is willing to host GASS data.

- **Enhanced communication with WGNE and WWRP:**

meeting with WWRP and WGNE leaders; direct engagement of them in developing GASS projects; gave GASS updates at their SSG meetings; GASS Panel member Irina Sandu has a joint membership in GASS and WWRP Polar Program Committee.

- **Pursuit of collaboration with the WCRP CFMIP:**

Zeng gave an invited talk at CFMIP Conference, followed by the conversation on future joint projects.

How we initiated projects:

Bottom up…
Motivate groups to write white paper,
Iterate with GASS panel,
Iterate with other international programs (if relevant),
Iterate with the GASS community of 500+ scientists in the email list,
Define deliverables and stages

- Only when ready, we launch

Project descriptions and white paper:
https://www.gewex.org/panels/global-atmospheric-system-studies-panel/gass-projects/

GASS Projects Launched in 2018

Surface drag and momentum transport (COORDE)

Impact of initalized land temperature and snowpack on sub-seasonal to seasonal prediction (LS4P)

Demistify: An LES & NWP fog modelling intercomparison

Improving the simulation of diurnal and sub-diurnal precipitation over different climate regimes

GASS Project to be Launched in 1st half of 2019

Second phase of the "Grey Zone" project based on the EUREC4A and phase III of the GATE field campaigns

COnstraining ORographic Drag Effects (**COORDE**)

Annelize van Niekerk (Met Office) & Irina Sandu (ECMWF)

Joint with WGNE

Understanding the effects of resolved and parametrized orographic drag through the ***COORDE***-nation of different modeling groups.

Aims:

- Expose differences in orographic drag parametrization formulation between models
- Understand impacts of differences in orographic drag parametrizations for modelled circulation
- Use high resolution simulations to quantify drag from small-scale orography, typically unresolved in models used for climate/seasonal projections, in order to evaluate orographic drag parametrizations
- Understand differences in resolved and parametrized orographic drag across models

Protocol: https://osf.io/37bsy/

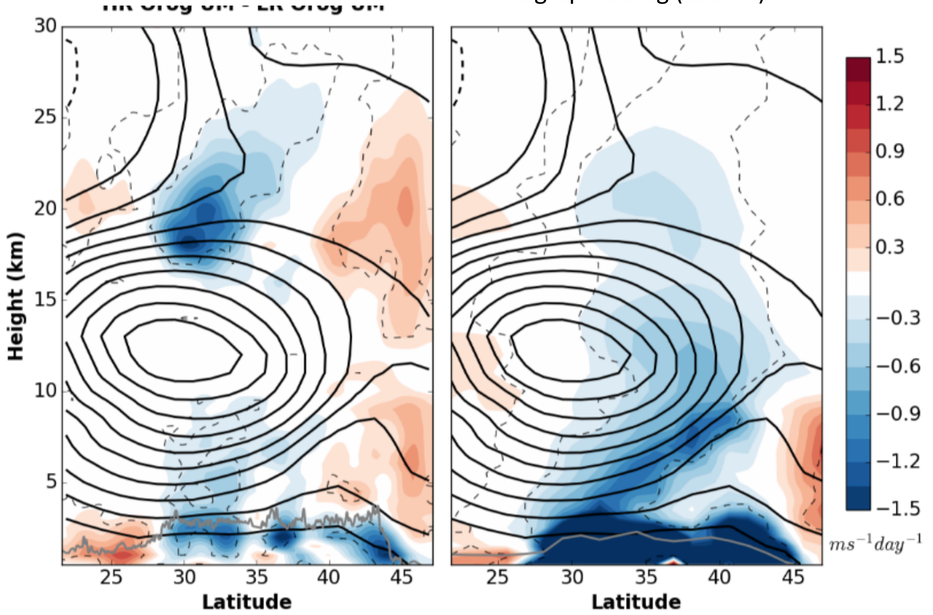
An article was published in GEWEX News in February 2019 issue

Protocol released: September 2018
Confirmation & experiment description received: Nov 2018
First set model output (low resolution simulations) requested by end of January 2019
Second set of model output (high resolution simulations) requested by end of February 2019

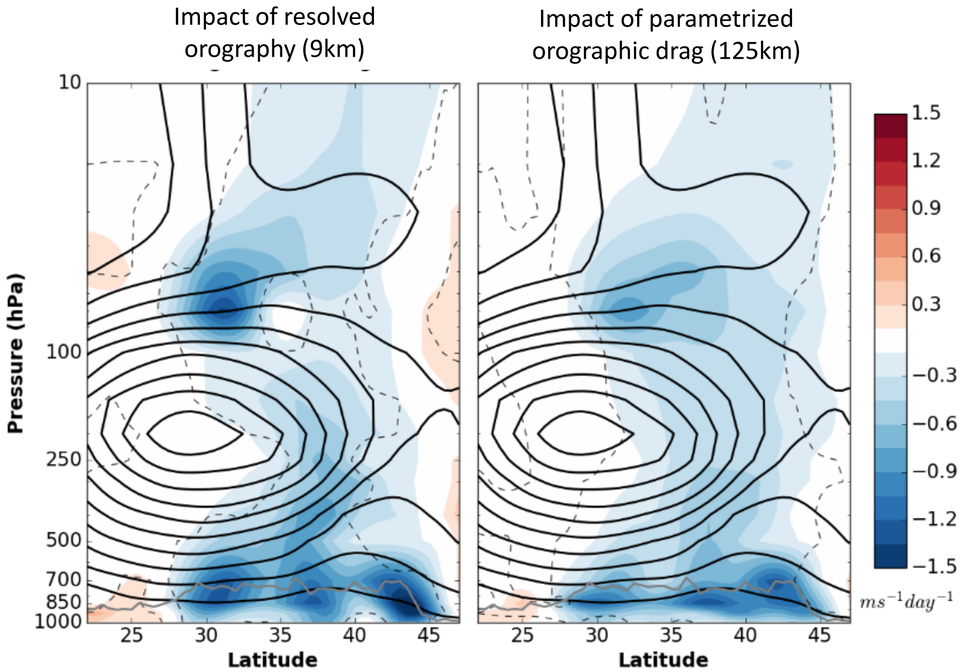
✓= Submission of data received

Centre	Model	Low resolution		High resolution	
ECMWF	IFS	125km	✓	9km	✓
Met Office	UM	150km	✓	1.8km/4km	✓
KIAPS	KIM	100km	✓	6km	
JMA	GSM_1705 GSM_19XX	120km 120km	✓ ✓	/ 10km	 ✓
DWD	ICON	40km		2.5km	
Meteo-France	ARPEGE AROME	80km /		/ 2.5	
Environment Canada	GDPS	100km	✓	3km	
NOAA/NCEP	GFS NGGPS WRF	100km 100km /	✓ ✓	/ / 3km	
NCAR	CESM	100km		/	

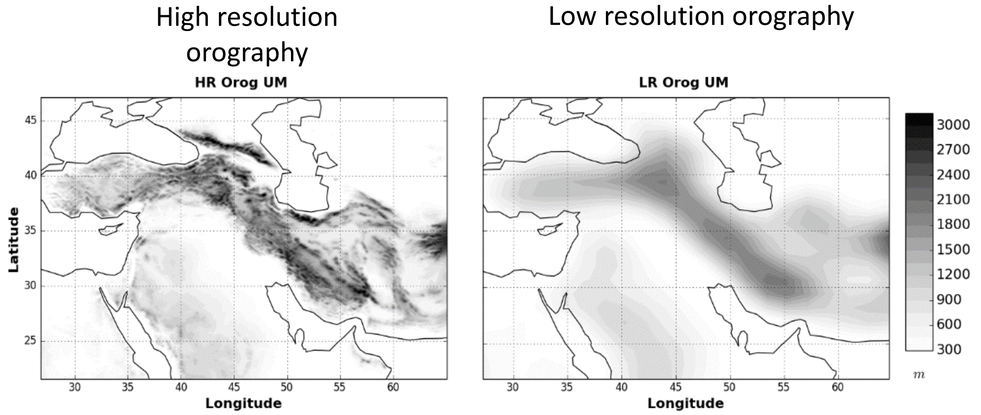
Met Office UM



ECMWF IFS



van Niekerk et al. (2018), JAMES



Method:

1) High resolution experiments (4km / 9km) with high resolution and low resolution orography are used to determine impact of resolved orography on circulation

2) Low resolution experiments (150km / 125km) with and without parametrized orographic drag used to determines impact of parametrized orographic drag on circulation

Plots show the impact of small-scale resolved orography (left) and parametrized orographic drag (right) on zonal winds in two models.

Impact of initialized land temperature and snowpack on subseasonal to seasonal prediction (LS4P)

Yongkang Xue (yxue@geog.ucla.edu), Tandong Yao (tdyao@itpcas.ac.cn);
Aaron Boone (aaron.boone@cnrm.meteo.fr)

Good interaction with WWRP/WCRP S2S

Project Goals

- What is the impact of the initialization of large scale land surface temperature (LST)/subsurface temperature (SUBT), mainly in high elevation regions, and the aerosol in snow, in climate models on the S2S prediction over different downstream regions?

- What is the relative role and uncertainties in these land processes versus in SST in S2S prediction? How do they synergistically enhance the S2S predictability?

This LS4P project aims to pursue a new approach – complementing SST, snow, soil moisture, vegetation researches – in understanding and potentially predicting drought/flood events in the regions.

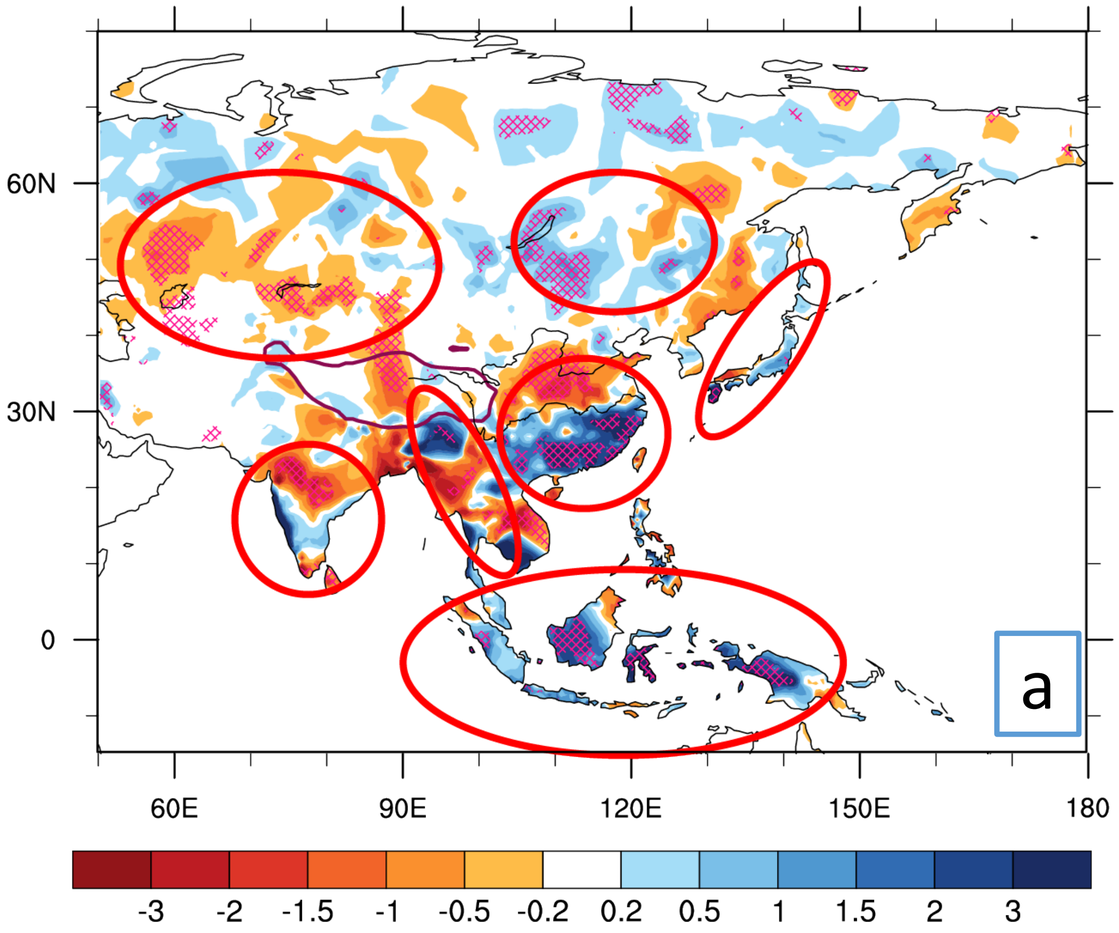
Initial focus on land temperature effect on S2S prediction – in partnership with "Third Pole Experiment Multi-Model Intercomparison" (TPEMIP).

The kick-off workshop was held in Washington, D.C. on 8-9 December 2018 (right before the AGU Fall Meeting).
An article was published in GEWEX News in February 2019 issue

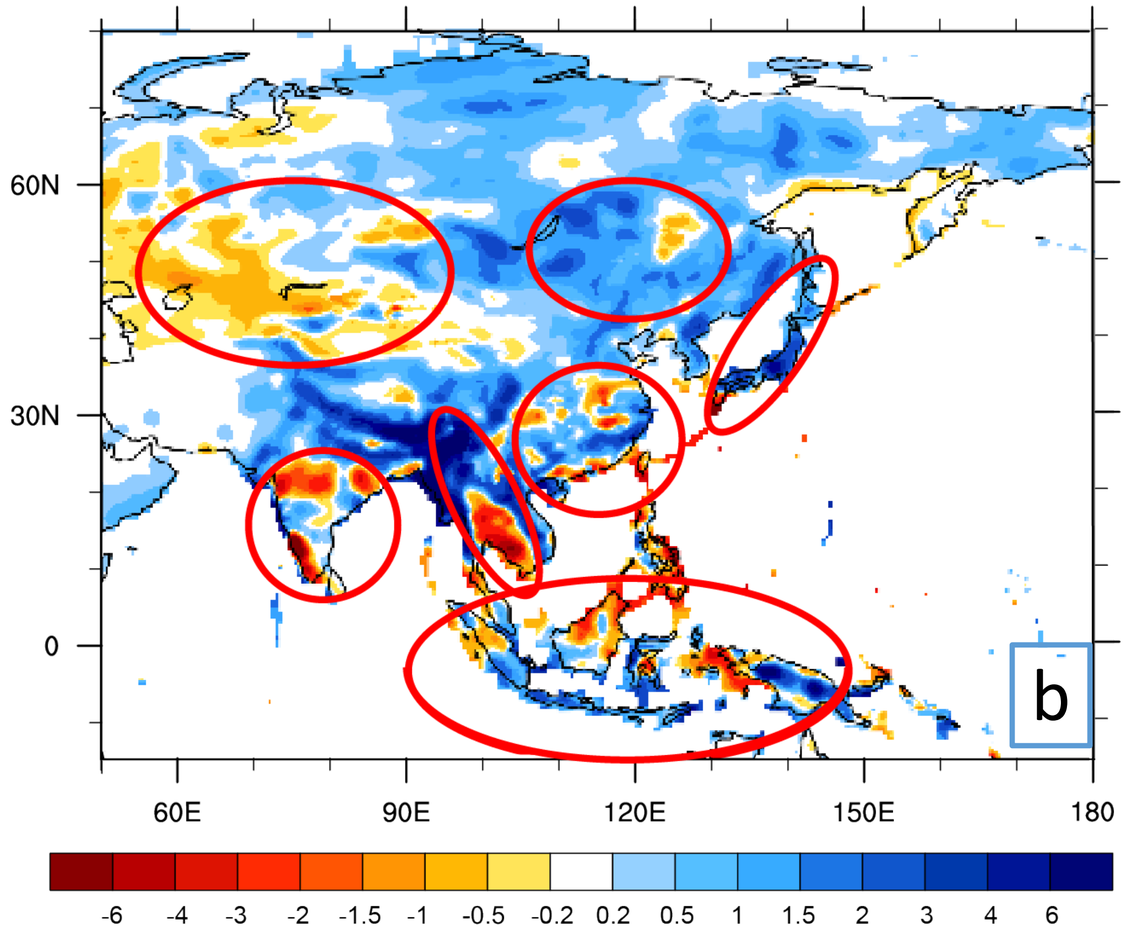
Participants – ESMs; Total 24

INSTITUTIONS	Contact Person	MODEL
BOM, Australia	Maggie Zhao et al.	Ukmet_au
CMA/NCC, China	Weiping Li	NCC GCM
CMA/NMC, China	Hongliang Zhang	NMC PRISM
CPTEC, Brazil	Paulo Nobre	BESM
DOE/LLNL, USA	Qi Tang et al.	DOE E3SM
ECMWF (TBC)	Gianpaolo Balsamo et al.	ERAS
Environment Canada	Hai Lin, R. Muncaster	ECCC-GEPS
ETHZ, Swaziland (TBC)	Sonia Seneviratne	ETHZ GCM
GFDL/NOAA, USA	Sarah B. Kapnick	GFDL FV3
Hokkaido University, Japan	Tetsu Nakamura	AFES v4.1
IITM, India	Subodh Saha	CFS (Indian Version)
KIAPS/KMA, Korea	Myung-Seo Koo, S.-Y. Hong et al.	KIM
KIT/IMK, Germany (TBC)	Anika Rohde	ICON

INSTITUTIONS	Contact Person	MODEL
Meteo France	Constantin Ardilouze et al.	CNRM-CM6
MRI, Japan	Yuhei Takaya	JMA/MRI-CPS2
NASA/GSFC, USA	Hailan Wang, Kyu-myong Kim	NASA GEOD-5
NCEP, USA	Weizong Zheng, Jack Kain	FV3GFS
Tsinghua University, China	Yanluan Lin et al;.	CIESM
LASG/IAP/CAS, China	Qin Bao, Jing Yang	LASG GCM. BNU
IAP/CAS, China	Zhaohui Lin	CAS-ESM
UCLA, USA	Yongkang Xue et al.	CFS/SSiB
UK Meto office (TBC)	Adam Scafie	Ukmeto ESM
UMD, USA	William K.-M. Lau	NASA GEOS-5
Univ. Arizaona, USA	Xubin Zeng, Mike Brunke	NCAR ESM

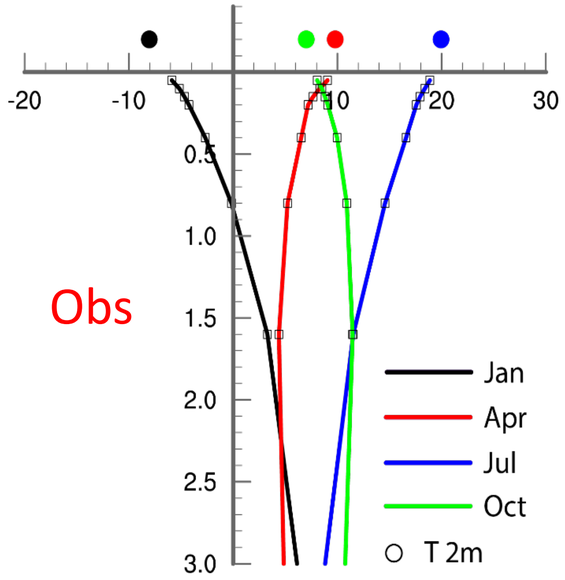


Observed June Precipitation difference between warm and cold years in May 2-m Temperature (T-2m) over the Tibetan Plateau.

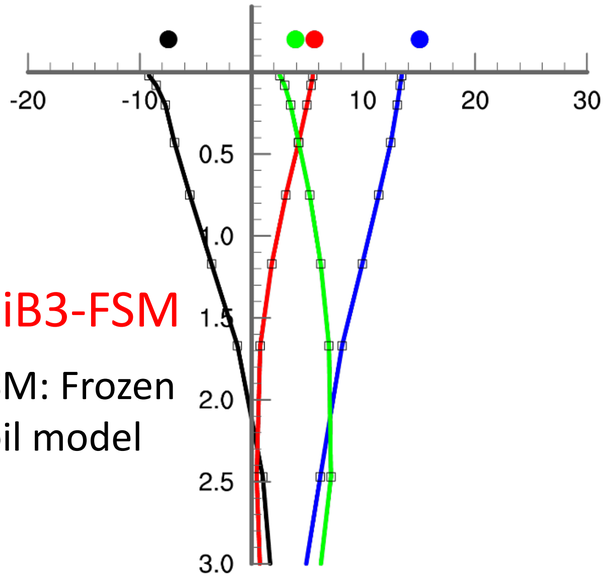


Multi-model ensemble mean June Precipitation bias when models have warm bias over the TP. For models with negative T-2m bias, the precipitation bias is multiplied by -1 to be included in the composite.

Soil temperature profiles in different seasons based on 14 TP stations

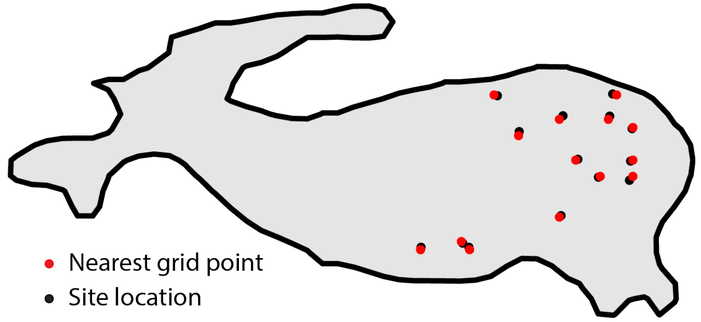


Obs

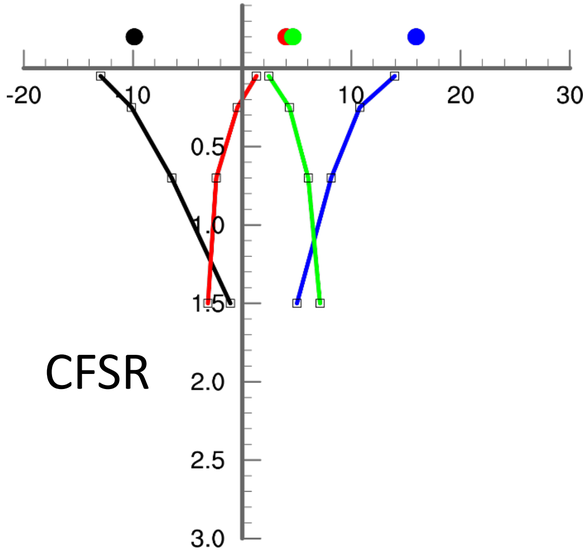


SSiB3-FSM

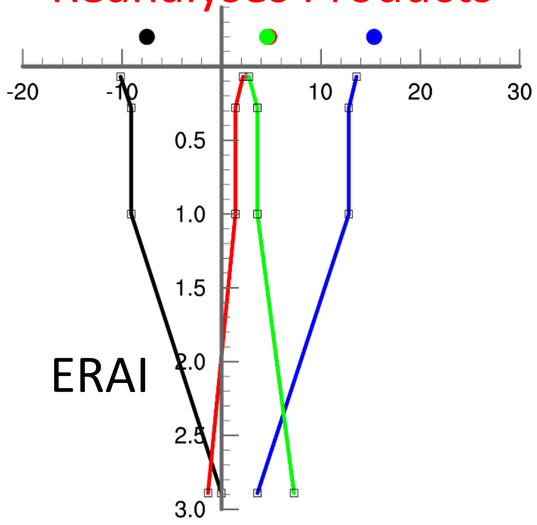
FSM: Frozen soil model



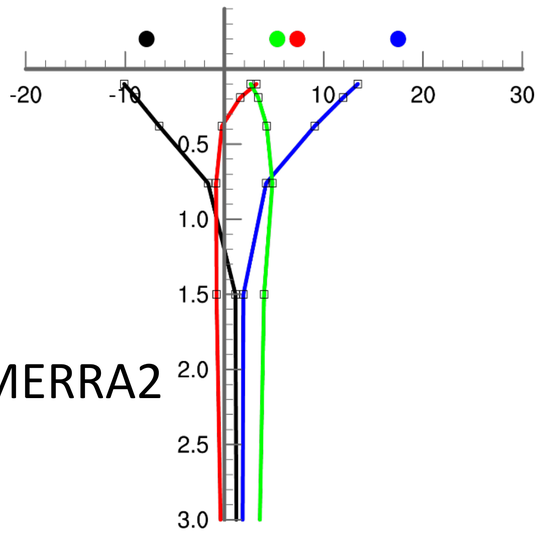
Reanalyses Products



CFSR



ERAI



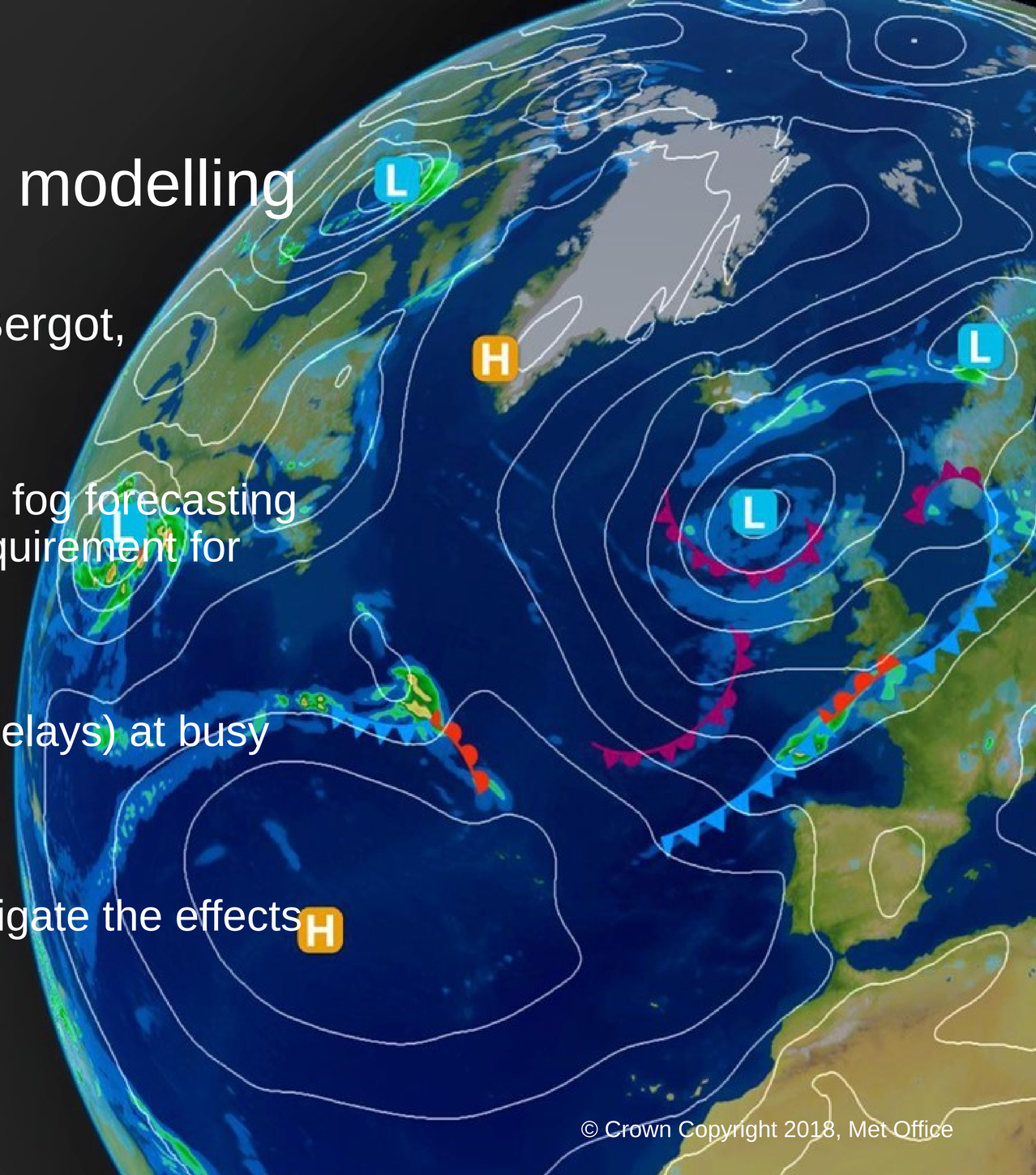
MERRA2

Demistify: an LES and NWP fog modelling intercomparison

Ian Boutle, A. Hill, S. Romakkaniemi, T. Bergot,

C. Lac, B. Maoronga, G.-J. Steeneveld

- Most operational NWP centres will list errors in fog forecasting amongst their top model problems, with the requirement for improvement considered high-priority.
- Aviation is the key customer driving this
- ~40% of all delays (~50% of weather relayed delays) at busy airports due to low visibility events
- Very expensive + lots of grumpy passengers
- With accurate forecasts, can plan ahead to mitigate the effects
- How can we improve our forecast accuracy?



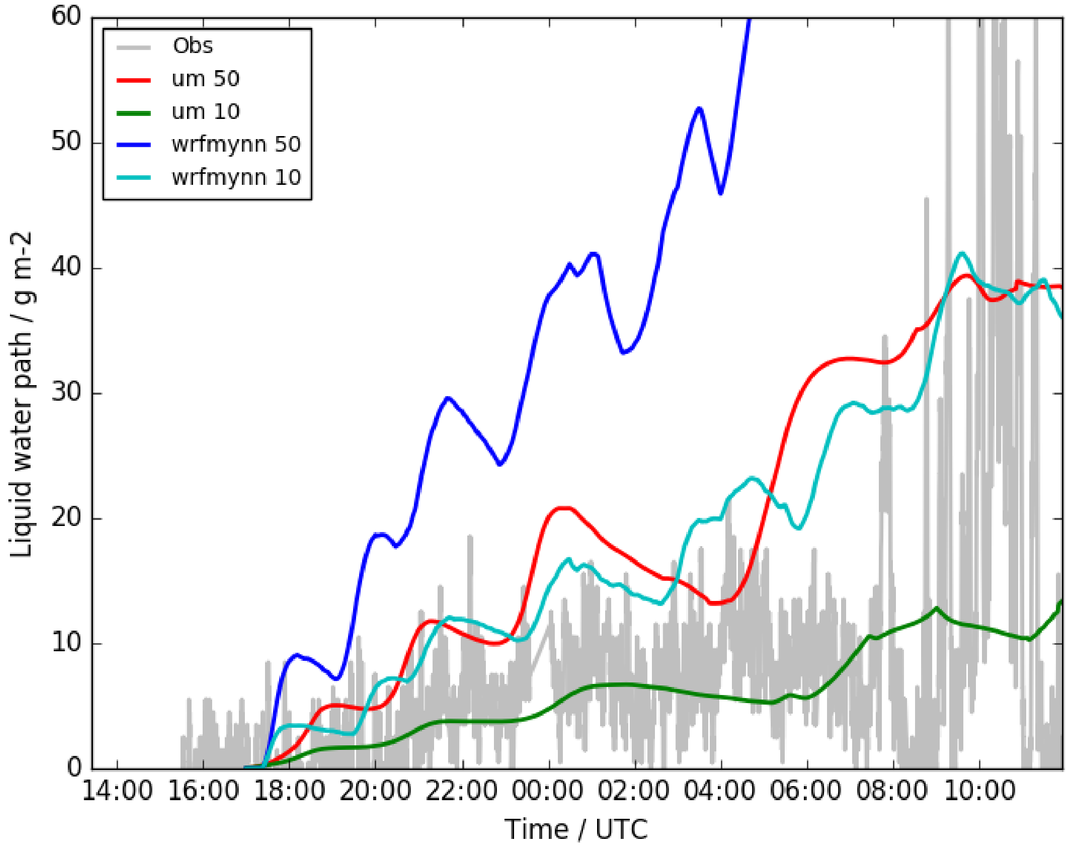
Background and aims

- Long history of LES & SCM intercomparisons under GASS/GCSS/GABLS
- Time would seem appropriate to bring stable boundary layer & cloud modelling communities together for a fog case
- Experimental design has been finalized.
- Key questions:
  - How well can models simulate the development of radiation fog?
  - What are the key processes governing the development of radiation fog, i.e. aerosol, cloud microphysics, radiation, turbulence, dew deposition, ...?
  - What level of complexity is required from NWP models to adequately simulate these processes?
  - What role does land-surface interaction play in the development of radiation fog?

Institute	NWP	LES	Participants	Submitted results?
Met Office	Met Office Unified Model (UM)	Met Office NERC Cloud Model (MONC)	Ian Boutle Adrian Hill	Yes (NWP only)
Meteo France	AROME/Meso-NH	Meso-NH	Christine Lac Thierry Bergot Benoit Vie Leo Duconge Yann Seity	Yes
FMI	HARMONIE-AROME	UCLA-SALSA	Sami Romakkaniemi Innocent Kudzotsa Laura Rontu Carl Fortelius	
Wageningen University	WRF		Gert-Jan Steeneveld	
Hannover University		PALM	Bjorn Maronga Johannes Schwenkel	Yes
DWD	ICON	ICON-LES	Tobias Goecke	Yes (NWP only)
Frankfurt University	COSMO	COSMO-LES	Juerg Schmidli	Yes (NWP only)
NOAA	WRF		Wayne Angevine	Yes
NOAA	FV3		Jian-Wen Bao Evelyn Grell	
ECMWF	IFS		Richard Forbes	
UC Davis		RAMS	Adele Igel	Yes
IITM	WRF		Sachin Ghude	

Some very preliminary results

- Already showing an interesting difference in fog development between UM and WRF
- WRF much deeper & optically thicker than UM
- Low CDNC (10cm^{-3}) WRF run looks similar to high CDNC (50cm^{-3}) UM run
- Huge divergence in fog by end of the night



Improving the simulation of the diurnal and sub-diurnal precipitation over different climate regimes

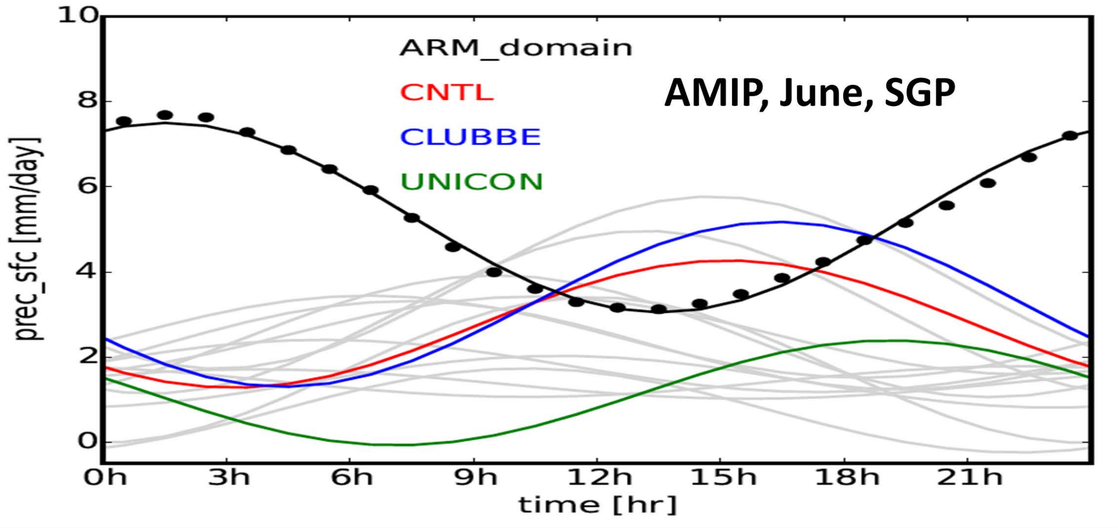
Shaocheng Xie, P. Bechtold, H.-Y. Ma, D. Neelin

- **Interaction between convection and water vapor**
  - *Which processes are most essential and how can these be improved in weather and climate models?*
- **Nocturnal convection over land**
  - *What is the role of convective memory (advection), elevated convection initiation, nighttime low-level jet, radiative cooling from cloud tops?*
- **Diurnal cycle of convection over ocean**:
  - *What is the role of the "direct radiation–convection interaction" (or lapse-rate) mechanism on diurnal cycle of convection over ocean?*
  - *What is the role of the "dynamic cloudy–clear differential radiation" mechanism?*
- **Convection transition**
  - *What controls the transition from shallow to deep convection? Free tropospheric humidity or boundary layer inhomogeneity?*

Approach

- **A hierarchy modeling approach**
  - *SCMs, CRMs, LESs, Regional Models, Convection Permitting models, and GCMs*
- **Case studies vs. statistical studies**
  - *Major field campaigns*
  - *Multi-year simulations*
- **Short-range hindcasts vs. climate simulations**
  - *The Transpose-AMIP or CAPT approach with models initialized with NWP analysis*
  - *Free AMIP type of runs*
- **Observational studies and modeling tests**
- **Process oriented diagnosis**
  - *Convection onset diagnosis*

A Missing Summertime Nocturnal Precipitation at SGP



Black: ARM;
Grey lines: CMIP5 model results,
Colors for E3SM with different convection schemes

Project Activities

- Developed and shared the project white paper within GASS
- Formed a core team including more than 10 modeling groups
- Further solicited input from the core team for kicking-off the project
- Developed separate experiment design documents for SCM/CRM/LES model intercomparison and GCM intercomparison
- Circulated the experiment documents within GASS and other GEWEX communities
- Created a project homepage *http://portal.nersc.gov/project/capt/diurnal/*

Timelines:

March 1, 2019: Finalize experiment documents for the project to start

31 October, 2019: Deadline for data submission from participants

GEWEX Process Evaluation Study

on Upper Tropospheric Clouds & Convection

GEWEX UTCC PROES

advance understanding on feedback of UT clouds

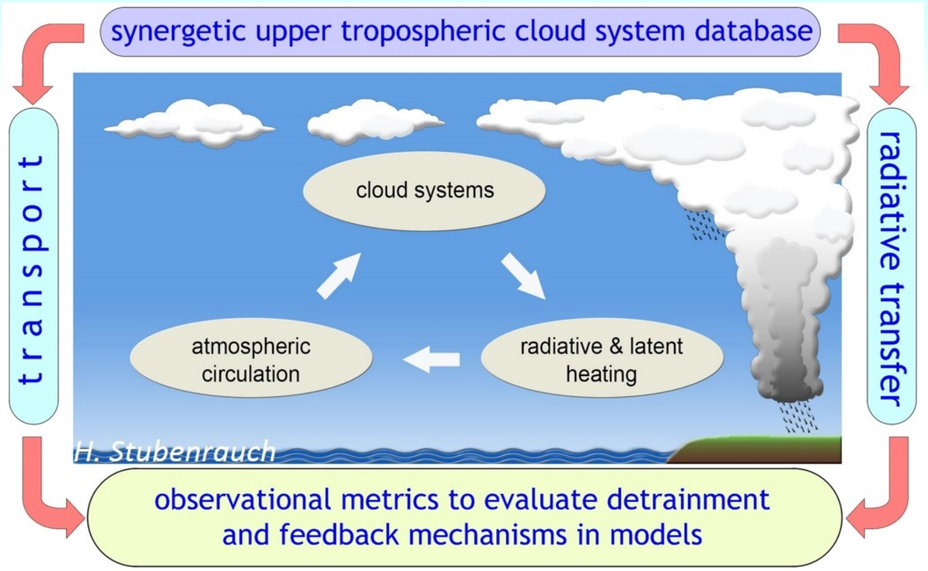
large-scale modelling necessary to identify most influential feedback mechanisms

-> models should be in agreement with observations

- ***understand relation between convection, cirrus anvils & radiative heating***
- ***provide observational metrics to probe process understanding***

Claudia Stubenrauch

Laboratoire de Météorologie Dynamique / IPSL, France



UTCC PROES Strategy

meetings: Nov 2015, Apr 2016, Mar 2017, Oct 2018

***working group* links communities** from observations, radiative transfer, transport, process & climate modelling

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

- **Cloud System Concept, anchored on IR sounder data**
  (horizontal extent & convective cores/cirrus anvil/thin cirrus ***based on*** p_{cld}, ε_{cld})
  -> relationships between anvil properties & convective strength
- **build synergetic data** (vert. dimension, atmosph. environment, temporal res.)
- **determine heating rates** of different parts of UT cloud systems
- **follow snapshots** by Lagrangian transfer -> **evolution & feedbacks**
- **investigate how cloud systems behave in CRM studies**
  & in GCM simulations *(under different parameterizations of convection/detrainment/microphysics)*

GEWEX UTCC PROES highlights 2018

- **UTCC PROES website: https://gewex-utcc-proes.aeris-data/fr**
  goals, meeting presentations, references, links

- **3rd GEWEX UTCC PROES meeting**

hosted by C. Stubenrauch, Sorbonne University, Paris, 22 – 23 Oct 2018 *30 participants*
Observational analyses of mesoscale convective systems, Water vapor & convective transport, Process studies, Climate variation & feedbacks, Parameterizations & model diagnostic studies

- very positive feedback from participants on continuing these meetings (-> collaborations)
- link to SPARC ?
- 2019: write review article on this topic & promote process-oriented cloud system diagnostics to be used as additional constraint in evaluation of climate model parameterizations

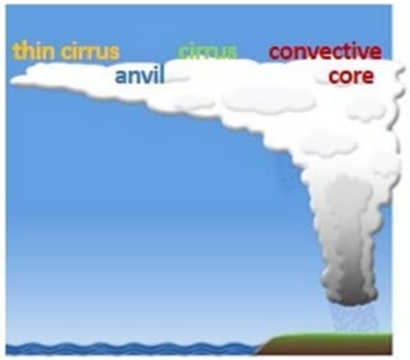
UT Cloud System Concept to assess GCM parameterizations

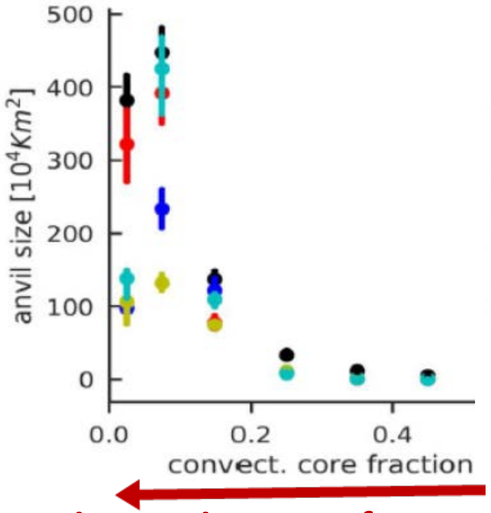
analyze GCM clouds as seen from AIRS/IASI, via simulator *M. Bonazzola, LMD*

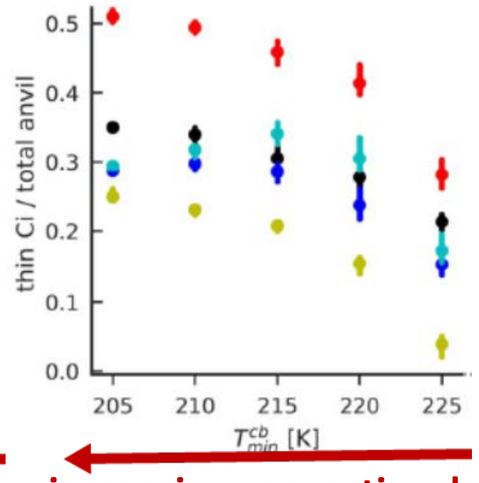
& construct UT cloud systems

-> evaluation of GCM convection schemes / detrainment / microphysics

process-oriented UT cloud system behaviour







Data

control v_m =0.3 x f(IWC)
D_{eff} = f(T)

empirical v_m & D_{eff} = f(v_m)

PSDM v_m & D_{eff} = f(v_m)

PSDM v_m, D_m & D_{eff} = f(D_m)

Stubenrauch et al., JAMES, subm. Jan 2019

increasing age of system **increasing convective depth**

New process-oriented diagnostics based on Cloud System Concept powerful constraint:

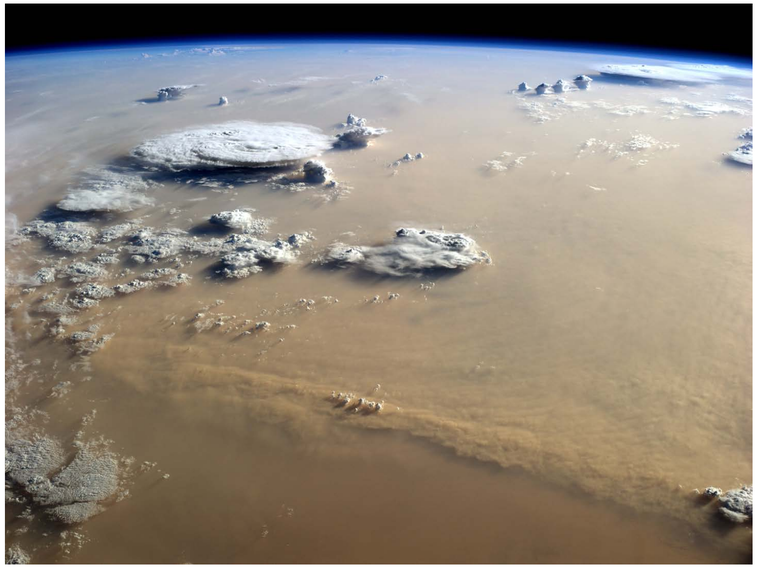
more realistic bulk ice schemes (coherently linking bulk fall speed v_m & effective ice crystal diameter D_{eff}) lead to more realistic development of anvil size & horizontal structure (increasing thin Ci)

GAP

- GAP = GEWEX Aerosol Precipitation
- A new GEWEX initiative being co-chaired by Sue van den Heever (CSU) and Philip Stier (Oxford)

Sue van den Heever

Philip Stier



GAP

Sue van den Heever and Philip Stier

GAP GOALS

1. Enhance our understanding of aerosol-precipitation interactions on a regional to global scale with a focus on energetics and water budgetary constraints in a regime based context
2. Facilitate connections between all GEWEX cloud-aerosol-precipitation activities
3. Interface with iLeaps/GEWEX/IGAC Aerosols, Clouds, Precipitation and Climate (ACPC) initiative
   - ACPC goal is to investigate aerosol and cloud processes on a local to cloud system scale
   - Stier and van den Heever are on the ACPC steering committee thereby facilitating GAP – ACPC communication

GAP

Sue van den Heever and Philip Stier

GAP Activities

- Series of small round table meetings:
  - At the ACPC workshop held in Oxford in April 2016
  - Expert GAP workshop held in Oxford on 28-30 June 2017
  - Next workshop: GAP is in discussion with GASS regarding an appropriate location and date for a collaborative GASS-GAP meeting
- A manuscript outlining the results from the workshop in 2017 (see next slide) has been written and will be submitted to Nature Geoscience following the completion of reviews by the GAP working group
- A white paper outlining GAP's "Grand Science Challenges" is also being developed - based on the review paper
- Once these two documents are complete, the goals and strategies of the white paper will be implemented

GAP Workshop 2017 Outcomes

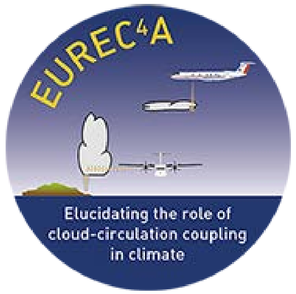
- Evidence and scientific consensus for a comprehensive set of proposed (1) microphysical and (2) radiative mechanisms was addressed at the workshop
- As global mean precipitation is energetically constrained, there is broad consensus and strong theoretical evidence that aerosol radiative effects act as drivers of precipitation - is less clear whether the resulting effects on precipitation are (1) applicable to smaller scales and (2) are buffered by compensating mechanisms
- While there is general agreement and good evidence that aerosols increase water droplet and ice crystal numbers, the effect on cloud microphysics and the subsequent impact on local, regional and global precipitation is not as well constrained.
- Future research should (1) define numerical model tests based on existing and future observations, and (2) establish methodologies to connect local scale effects to regional and global precipitation.

GAP

Sue van den Heever and Philip Stier

Second phase of the "Grey Zone" project based on the EUREC4A and phase III of the GATE field campaigns – joint with WGNE

Scale-awareness, stochasticity and convective organization



Jan/Feb 2020
Investigate how shallow cumulus clouds respond to changes in their large scale environment

Aug/Sep1974
Scale interactions between convective and the large-scale atmospheric circulation

Discussion of final experiment setup at UCP2019 conference in Berlin (25 Feb 2019).

Project meeting at the ParaCon convection conference in Exeter (15 Jul 2019).

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Direction of future GASS projects

Potential Gaps:

- Dynamics-physics coupling (White Paper prepared)
- Stable boundary layer (follow-up on GABLS3/4); e.g. around the MOSAiC campaign over the Arctic– under discussion
  -- Papers on GABLS4 are still on progress, with three papers (SCM, Land model, LES) under preparation.
- Joint effort on the surface flux project of WGNE along with other programs
- Radiation: circulation coupling; interaction between radiation and clouds
- High Impact and Extreme Weather: role of convective scale models; ensembles; relevant challenges for model development
- Processes relevant for polar prediction: mixed-phase clouds, coupling to the surface

Direction of future GASS projects

Partnerships:

WGNE: **Joint** “Drag” and “Grey-Zone” projects; **future**: atmospheric model bias reduction (?) surface flux project?

WWRP: Directly involved in “LS4P”, “Grey-Zone”, and other projects. Had good conversation on potential GASS-HiWeather connections

WWRP/WCRP S2S Project: the GASS GS4P project cooperated with S2S in the development of the white paper and implementation

ACPC: One mechanism is through the GEWEX Aerosol Precipitation (GAP) initiative

CFMIP: CFMIP and GASS collaborated on the CGILS project (CFMIP-GASS Intercomparison of LES and SCMs); Discussion ongoing on a potential joint project

Contributions to GEWEX Science Questions

a. Observations and Predictions of Precipitation

· Three existing GASS projects directly address precipitation: the precipitation diurnal cycle, land impact on S2S prediction, and GAP

· Two projects to be launched in 2019 will also address precipitation: the gray zone project and the physics-dynamics coupling project.

b. Global Water Resource Systems

· One GASS project (land impact on S2S prediction) is directly related to the global water resources systems

c. Changes in Extremes

· All GASS projects aim to improve weather and climate models, including their capability in studying weather and climate extremes

d. Water and Energy Cycles

· All GASS projects aim to improve weather and climate models, including their capability in studying the water and energy cycles

Contributions to WCRP including Current Grand Challenges

- Weather and climate extremes: All GASS projects aim to improve weather and climate models, enabling the modeling study of weather and climate extremes

- Water for the food baskets: Several current and planned GASS projects (precipitation diurnal cycle, land impact on S2S prediction, GAP, gray zone, and physics-dynamics coupling) address precipitation that is directly related to water for the food basket

- Clouds, circulation and climate sensitivity: UTCC, GAP, the gray zone project and the physics-dynamics coupling project (to be launched by GASS in 2019) are directly relevant to the study of clouds, circulation and climate sensitivity

- Near-term climate prediction: the GASS project on the land impact on S2S prediction is directly relevant to near-term climate prediction; the GASS COORDE project is also very relevant for prediction on all time scales.

Goals for Next Year

Initiate at least two new projects

Expand the panel by adding at least four new panel members

Increase cooperation with other international programs (particularly WGNE and WWRP) by attending both WGNE and WWRP steering group meetings and establishing 1 or 2 direct links (i.e. GASS representatives on WGNE and WWRP)

Questions for SSG

- What organizational structure would be most helpful for PROES to succeed?
  UTCC and GAP are part of GASS, and UTCC also reports to GDAP. How about WR?

  If these PROES projects are covered by GASS, should their leaders be GASS Panel members?

- We currently have six GASS Panel members (two co-chairs and four members leading the four GASS projects). We are ready to add a few Panel members not leading, but are interested in, GASS projects.

  We are seeking names (particularly for inclusion and diversity).

- GASS already has close interactions with WGNE and WWRP and some other programs.

  Are these interactions appropriate for GASS (e.g., considering the re-organization of WCRP)?