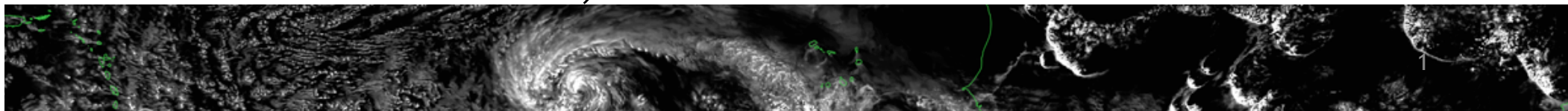
GEWEX Global Atmospheric System Studies (GASS)

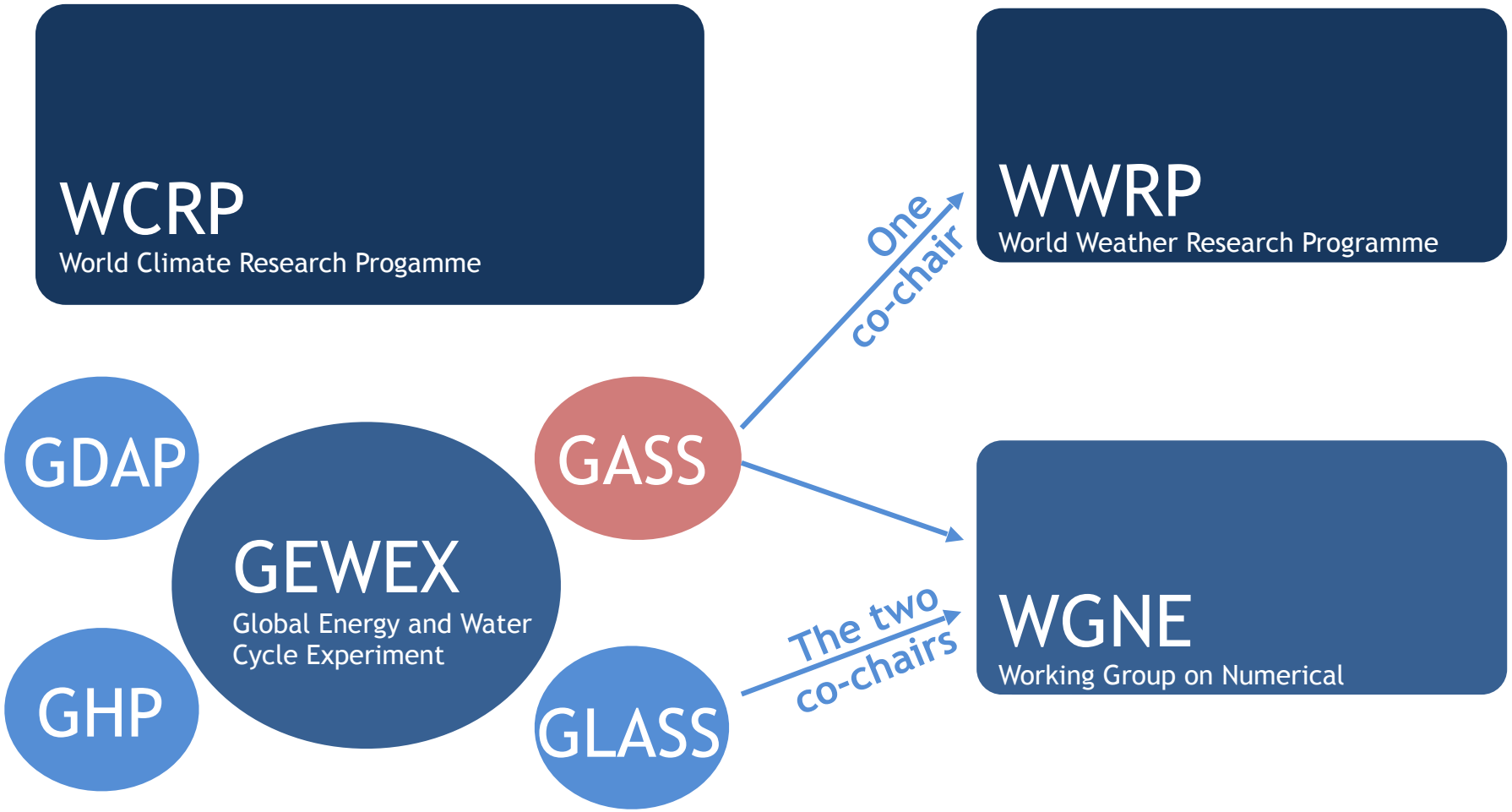
Xubin Zeng (Co-Chair, USA), Daniel Klocke (Co-Chair, Germany),
Irina Sandu (ECMWF), Shaocheng Xie (USA),
Ian Boutle (UK), Yongkang Xue (USA),
Sandrine Bony (France), Martin Singh (Australia)

Claudia Stubenrauch (France; leading UTCC PROES),
Eric Bazile (France; leading GABLS-4),
Sue van den Heever (USA, GAP)

27-30 Jan 2020
GEWEX SSG
Pasadena, California

GASS Global Atmospheric System Studies





GASS
Global Atmospheric System Studies

Science Objectives and Activities

Scientific Objectives of GASS:

to improve the understanding of physical processes in the atmosphere and their coupling to atmospheric dynamics.

Activities of GASS:

To facilitate and support international projects that use observations, process studies, and numerical model experiments to develop and improve the representation of the atmosphere in weather and climate models.

At present, GASS has five active projects with two more in the pipeline.

Two more projects (UTCC PROES and GAP) are affiliated with GASS.

GASS Global Atmospheric System Studies

Structure and Organization

GASS Panel Co-Chairs:

Xubin Zeng (USA), Daniel Klocke (Germany)

Members:

Irina Sandu (ECMWF), Shaocheng Xie (USA), Ian Boutle (UK), Yongkang Xue (USA), Sandrine Bony (France), Martin Singh (Australia), YESS-Member (pending)
Claudia Stubenrauch (France; leading UTCC PROES), Eric Bazile (France; leading GABLS-4), Sue van den Heever (USA, co-leading GAP PROES)

Current Projects:

- Surface drag and momentum transport (COORDE), led by Irina Sandu
- Impact of initalized land temperature and snowpack on sub-seasonal to seasonal prediction (LS4P), led by Yongkang Xue
- Demistify: An LES & NWP fog modelling intercomparison, led by Ian Boutle
- Improving the simulation of diurnal and sub-diurnal precipitation over different climate regimes, led by Shaocheng Xie
- GEWEX Upper Tropospheric Clouds and Convection Process Evaluation Study (UTCC PROES), led by Claudia Stubenrauch
- GEWEX Atmospheric Boundary Layer Study (GABLS-4), led by Eric Bazile

How do we initiate GASS 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

Key Results: GASS

- Four projects are entering the productive phase. Experiments are submitted and first analysis are being performed. They are highly related to the top three errors from WGNE Systematic Error Survey Results Summary
  --- Precipitation diurnal cycle, intensity and frequency
  --- Surface fluxes and temperature diurnal cycle
  --- Cloud microphysics

- GABLS-4 is in the final stage (under discussion for follow-up activities)

- Two Affiliated projects (UTCC PROES and GAP) are making progress.

- Two new panel members recruited, representing WCRP Grand Challenge (Sandrine Bony) and early-career scientist (Martin Singh).

Key Results: GASS

- Intensive communication with WGNE and WWRP and input to implementing WCRP reforms in terms of organising modelling activities across WCRP and coordinate with WWRP and WGNE.

- Close collaboration with the DOE ARM:
  --- ARM observations will be used in GASS projects;
  --- ARM is willing to provide small support for GASS-related meetings;
  --- ARM is willing to host GASS data and currently this is tested with data from the Demistify project

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Key Results: Surface drag and momentum transport project

COnstraining ORographic Drag Effects (COORDE):

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

Results were submitted by 8 modelling centres
-> impact of resolved orographic drag is similar across models. This gives faith in using the high resolution simulations to constrain parameterizations.

-> The parameterized orographic drag impact is diverse across models in terms of magnitude and position.

-> robust signal of insufficient/misplaced gravity wave drag in lower stratosphere in most models.

Protocol: https://osf.io/37bsy/
An article was published in GEWEX News in February 2019 issue

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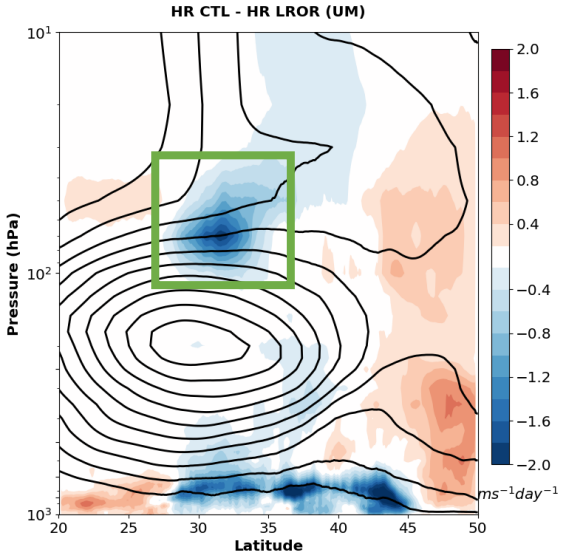
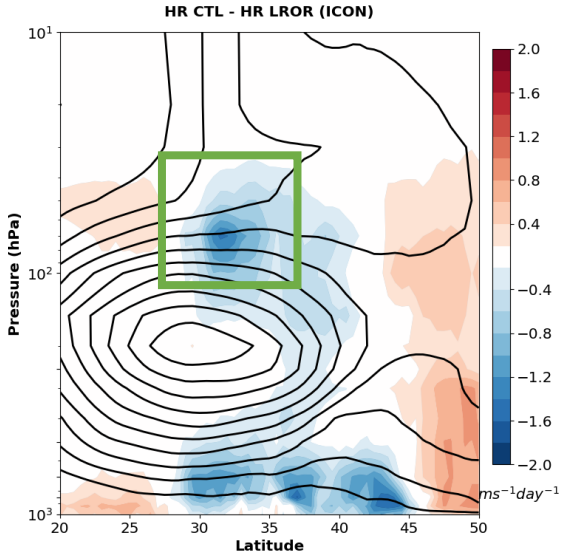
Impact of resolved orographic drag (Δx=1.8-10km)

Plots show impact on the zonal winds after 24 hours, longitudinally averaged over Middle East

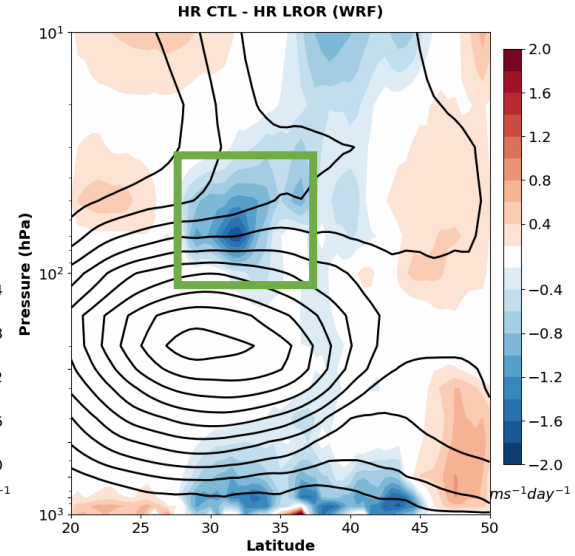
UM (1.8km)



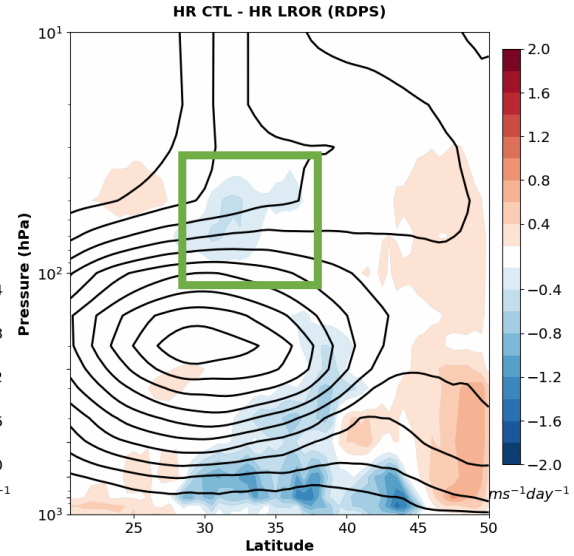
ICON (2.5km)



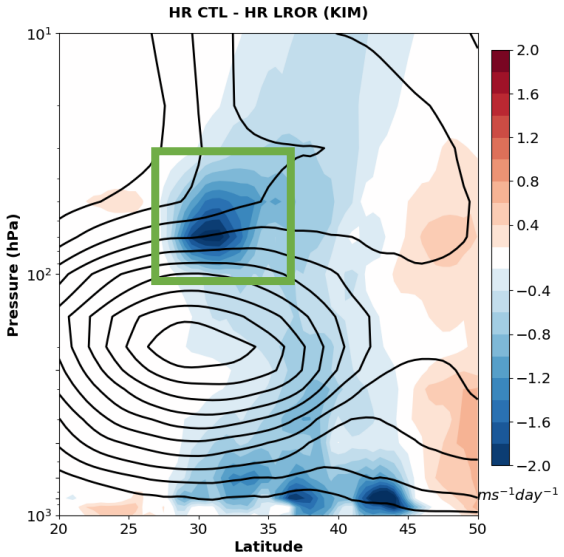
WRF (3km)



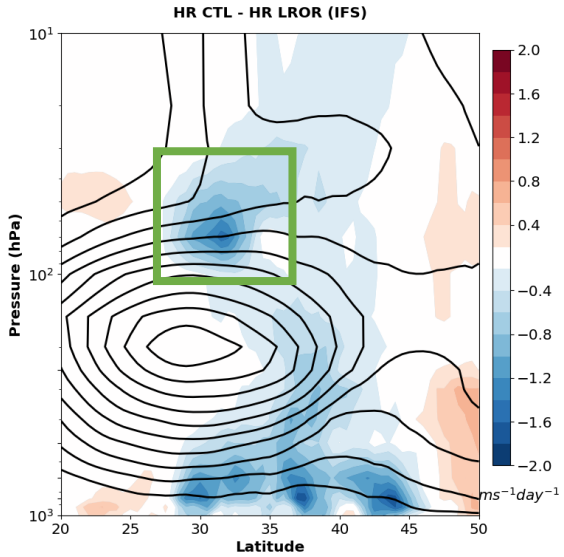
Env Canada (3km)



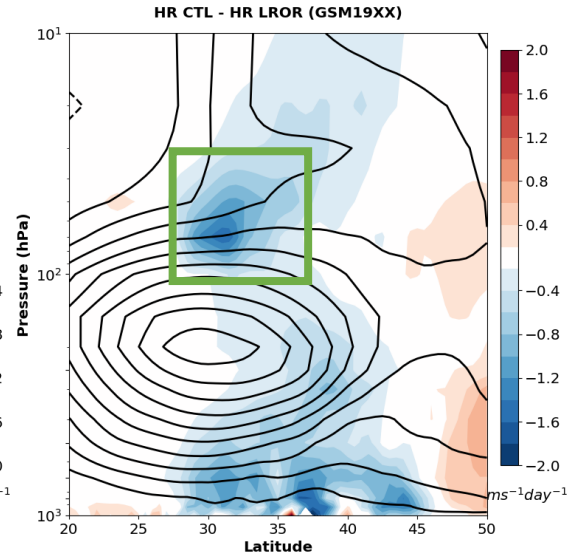
KIM (6km)



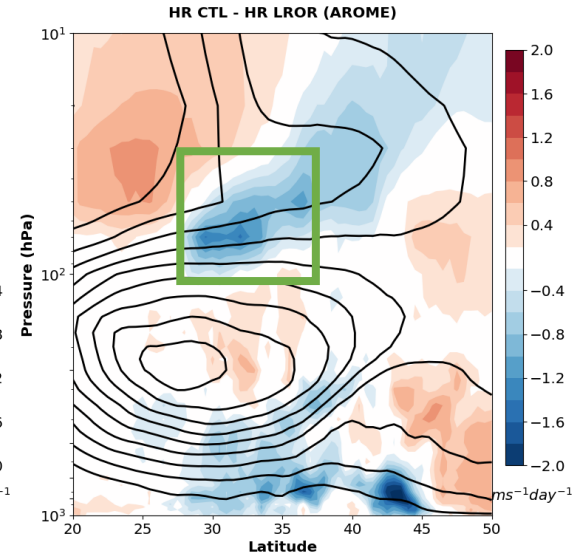
IFS (9km)



JMA (10km)



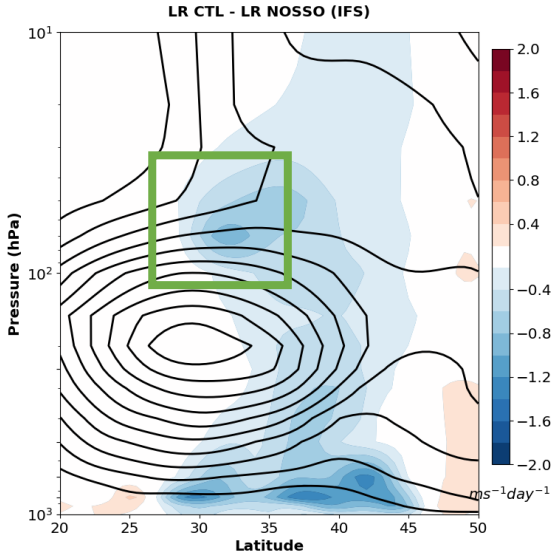
AROME (2.8km)



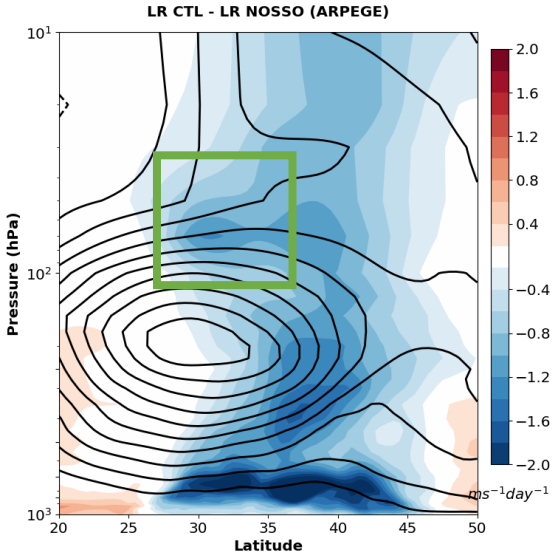
Impact of parametrized orographic drag (Δx=80-150km)

Plots show impact on the zonal winds after 24 hours, longitudinally averaged over Middle East

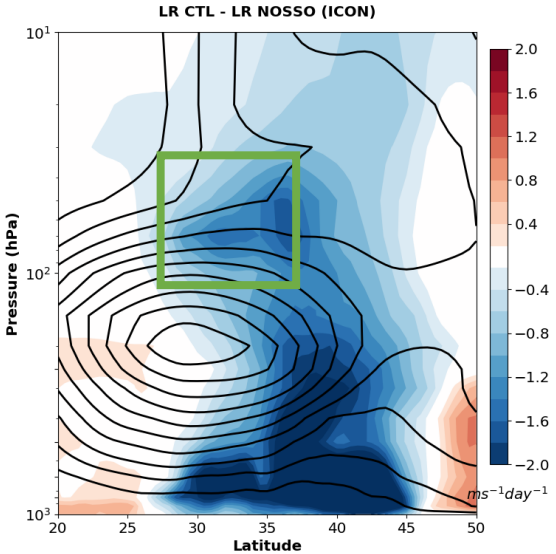
IFS



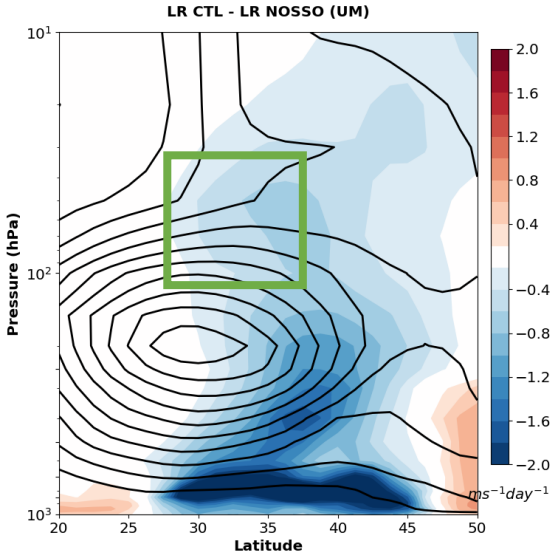
ARPEGE



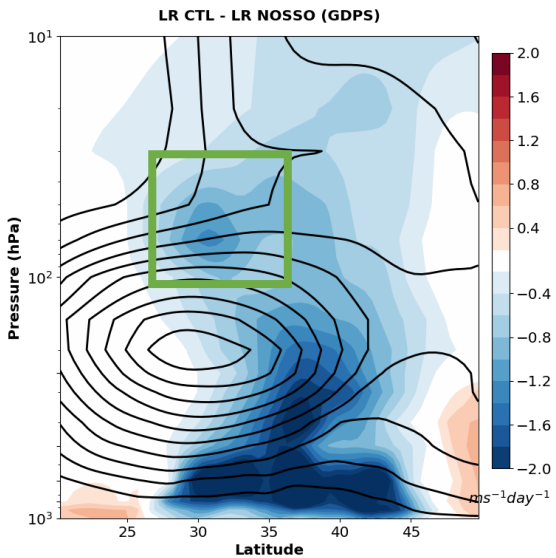
ICON



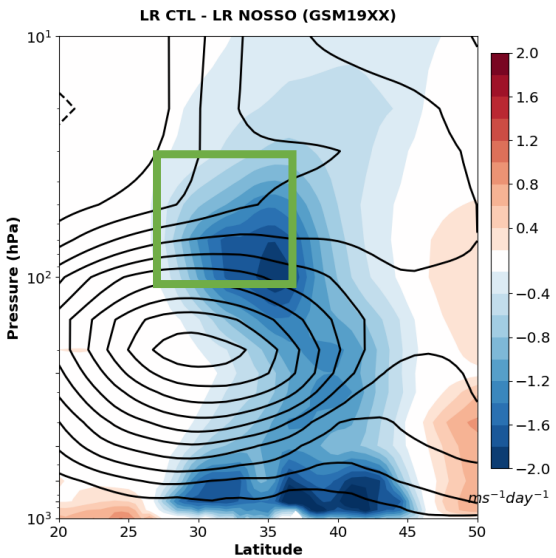
UM (Met Office)



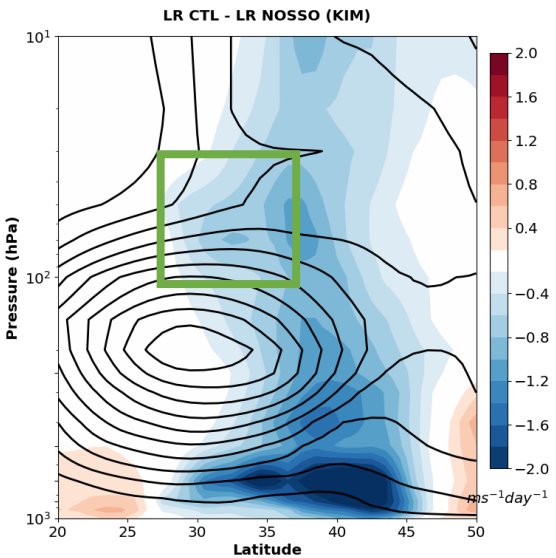
Env Canada



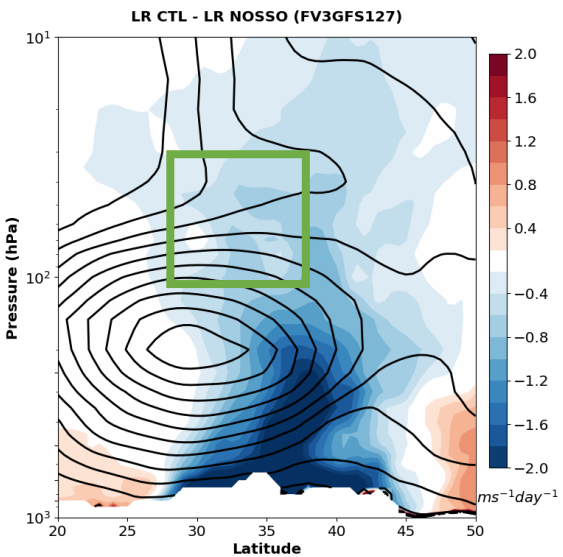
JMA



KIM (KIAPS)



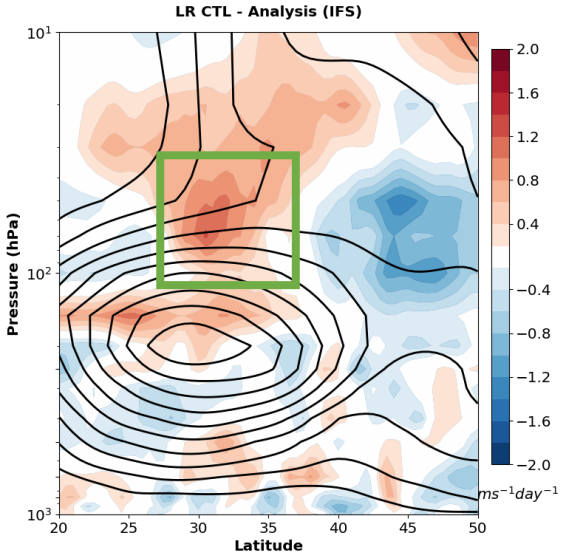
FV3 (NCEP)



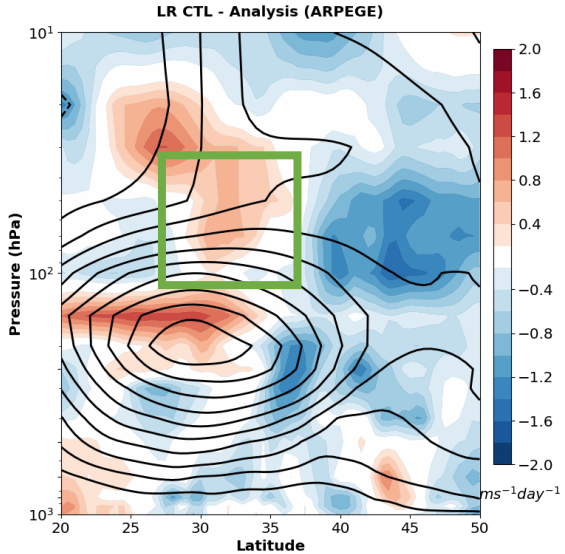
Model U error relative to analysis at T+24 (Δx=80-150km)

Plots show drift on the zonal winds after 24 hours, longitudinally averaged over Middle East

IFS



ARPEGE



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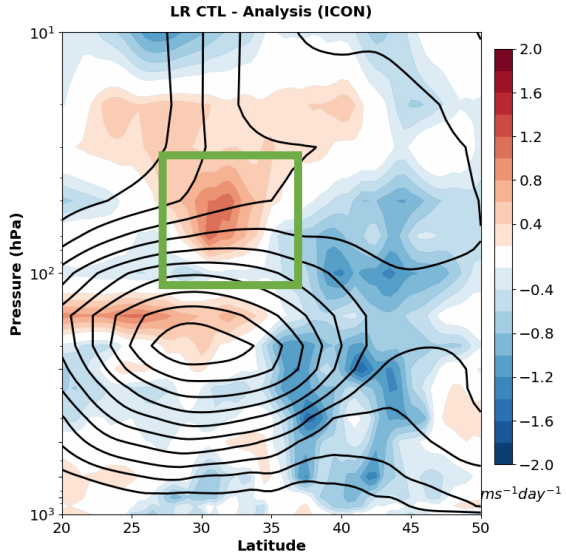

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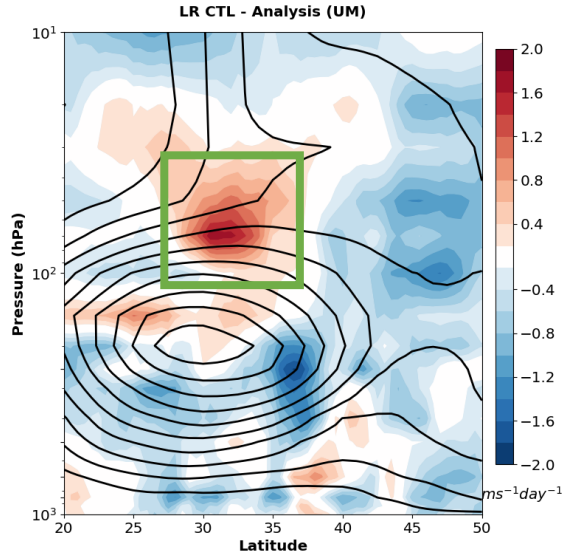
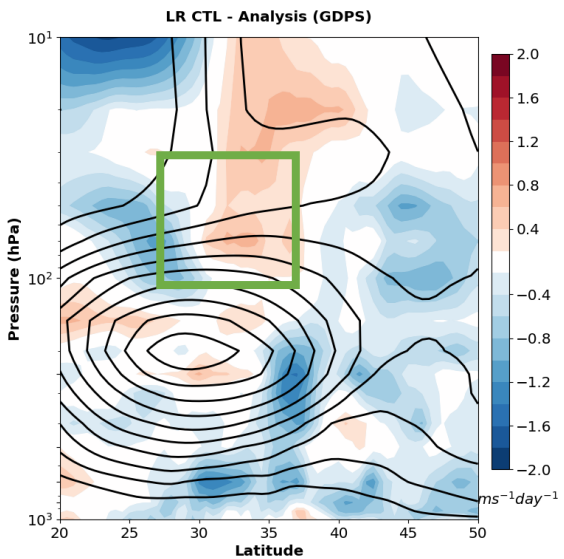
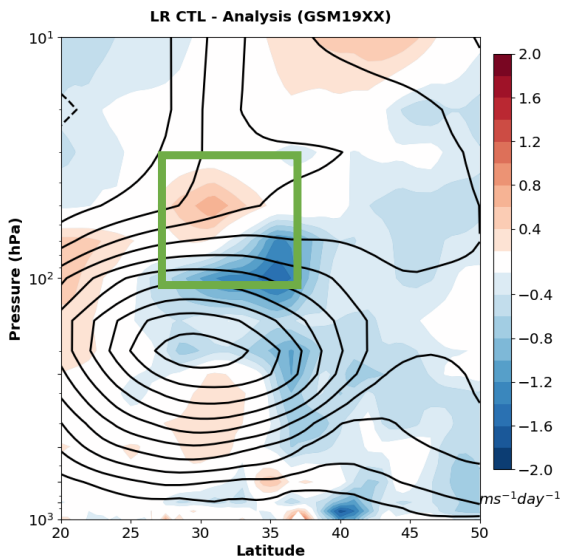


Env Canada



JMA



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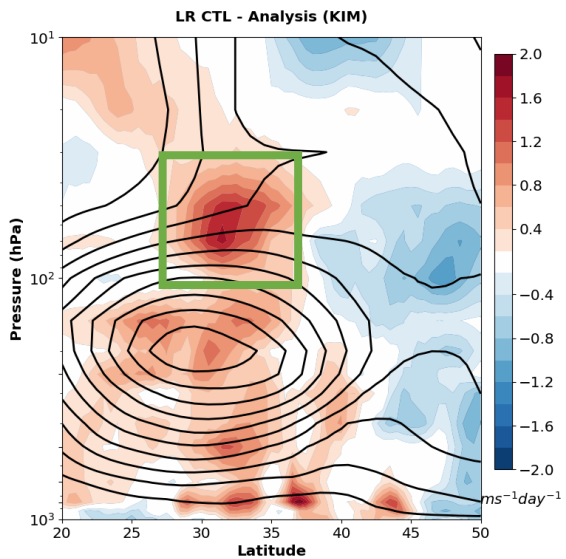
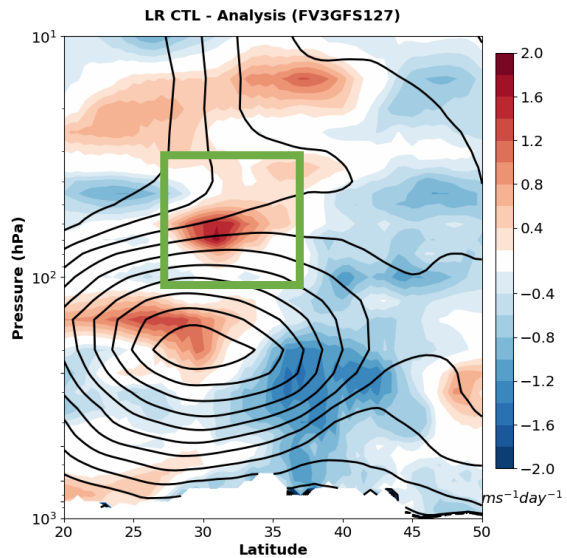


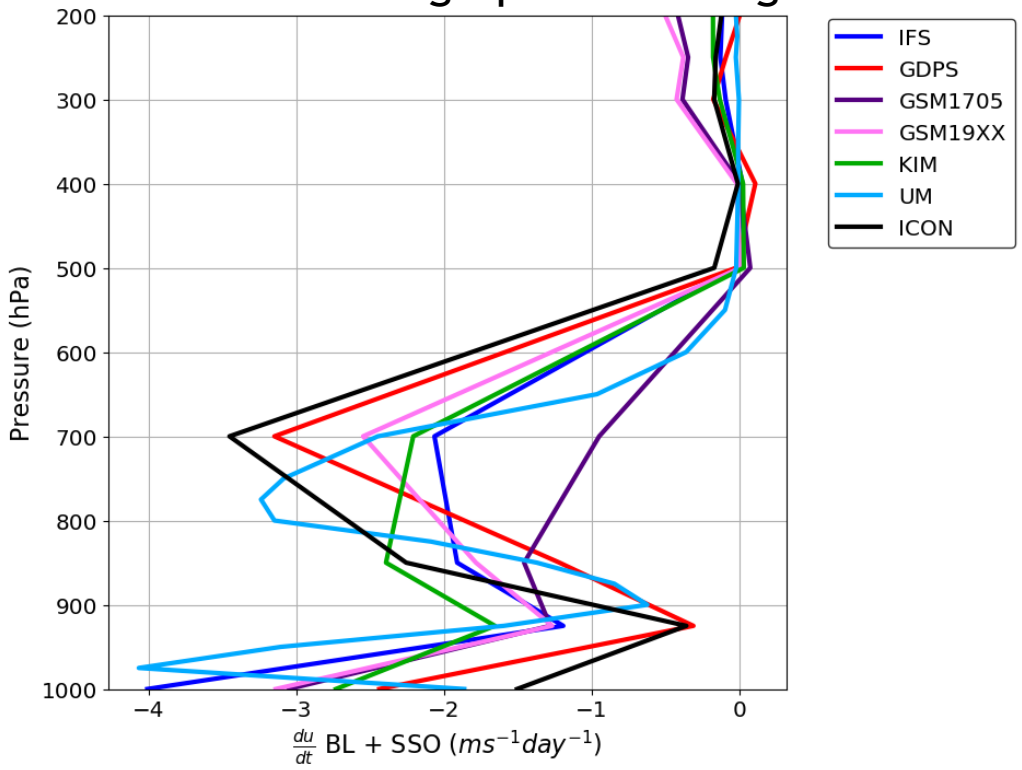
FV3 (NCEP)



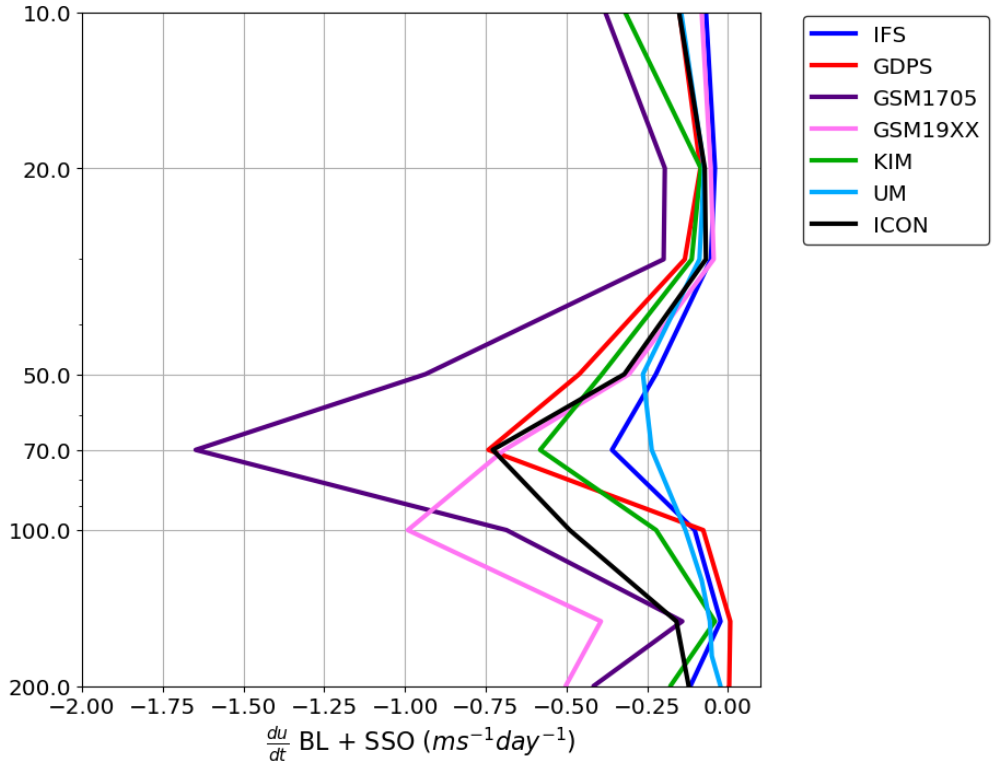
Key Results: Surface drag and momentum transport project

There is a large spread in the vertical distribution of the drag, with the UM and IFS having substantially less GWD in the upper atmosphere

Tendencies from boundary layer diffusion + orographic blocking



Tendencies from orographic GWD



Plots show tendencies averaged over Middle East region

Key Results: LES and NWP fog modelling intercomparison project

Demistify: LES and NWP fog modelling intercomparison:

Motivation: 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.

Results were submitted from 10 modelling centres
-> significant variations between models.

-> Not more consistency for LES than SCMs, suggesting microphysics & radiation as key causes (and not turbulence).

-> representation of cloud droplet sedimentation important. Aerosols not so important.

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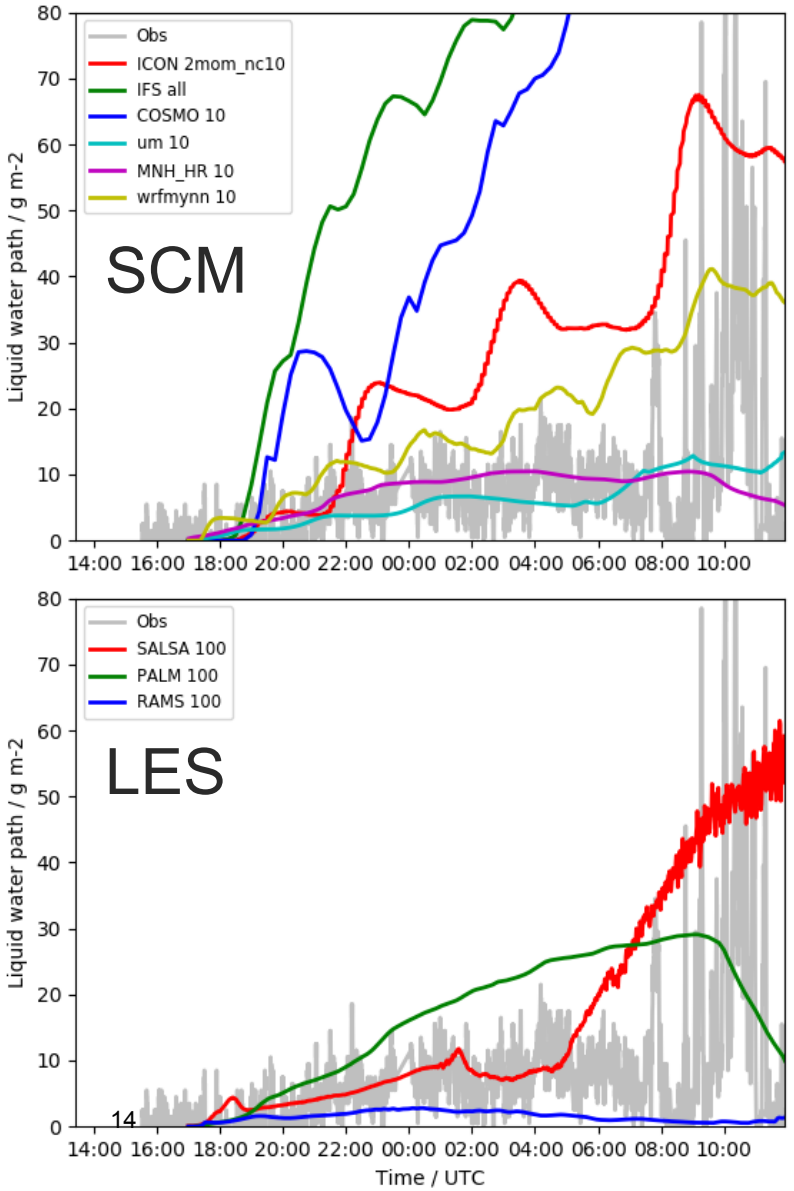
Key Results: LES and NWP fog modelling intercomparison project

- 10 models submitted – 6 SCM and 4 LES (more still expected & welcome)
- Analysis ongoing:
  - Significant variation between models
  - No more consistency for LES than SCMs, suggesting microphysics & radiation as key causes (not turbulence)
- Report drafted in December
- Project will advance slower next year (lead on leave)



Key Results: LS4P project (impact of init. land temperature and snowpack on S2S)

Goal: This project intends to address two questions:

(1) What is the impact of the initialization of large scale LST/SUBT and snow pack, including the aerosol in snow, in climate models on the S2S prediction over different regions?

(2) 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 project focuses more on the process understanding and predictability rather than the operational S2S prediction.

Results were submitted by 20 modelling centres

-> High elevation land surface and subsurface temperatures in the Third Pole region have substantial predictive capability for precipitation on S2S time-scales.

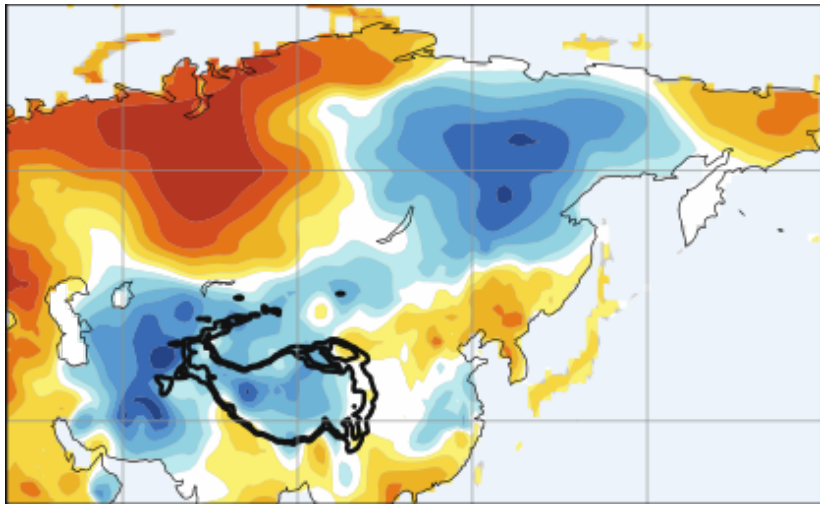
-> Impact on precipitation anomalies is global.

Two articles were published in GEWEX News (1st and 4th quarters, 2019).

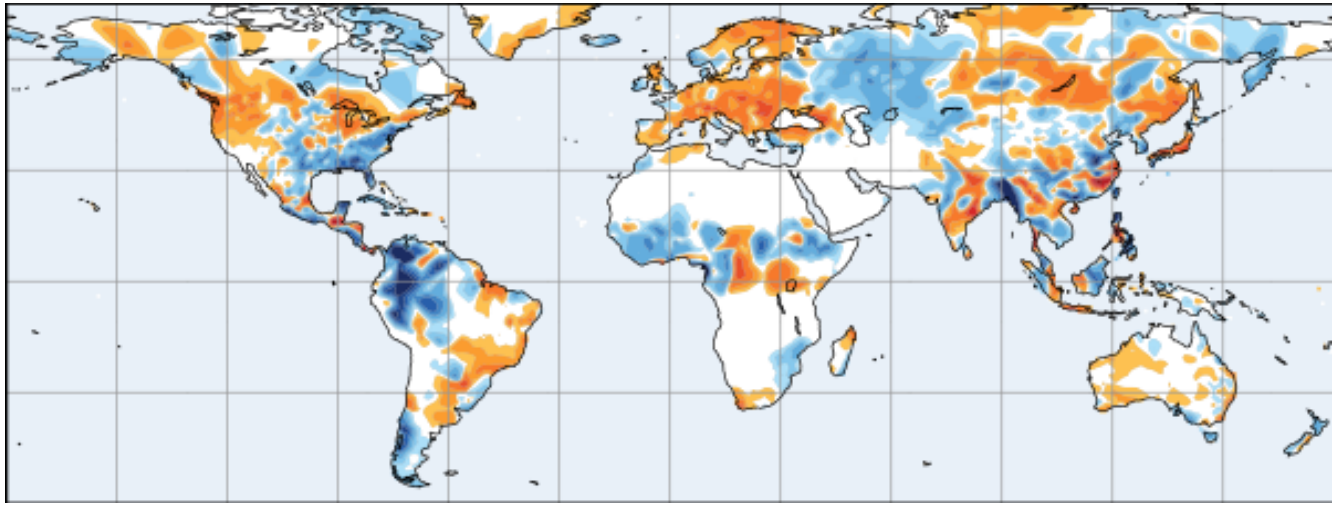
GASS Global Atmospheric System Studies

Comparison between observed anomalies and 20 LS4P Models ensemble mean BIAS

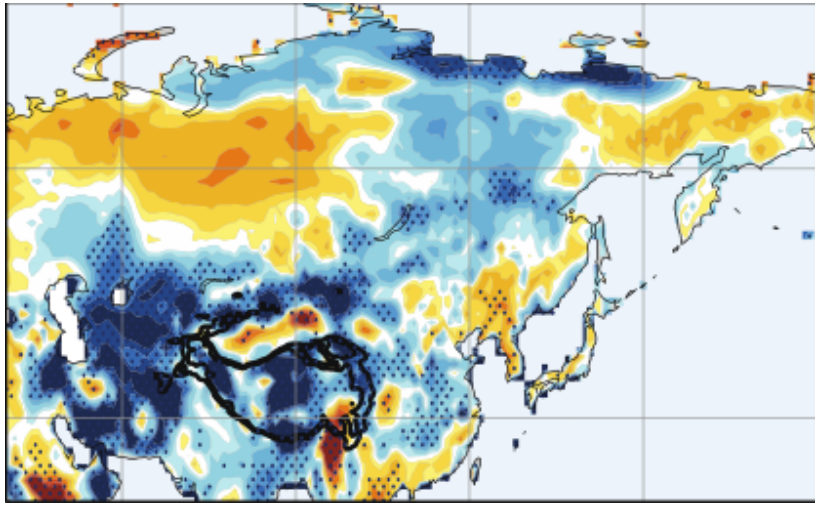
Observed May 2003 T-2m anomalies (°C)



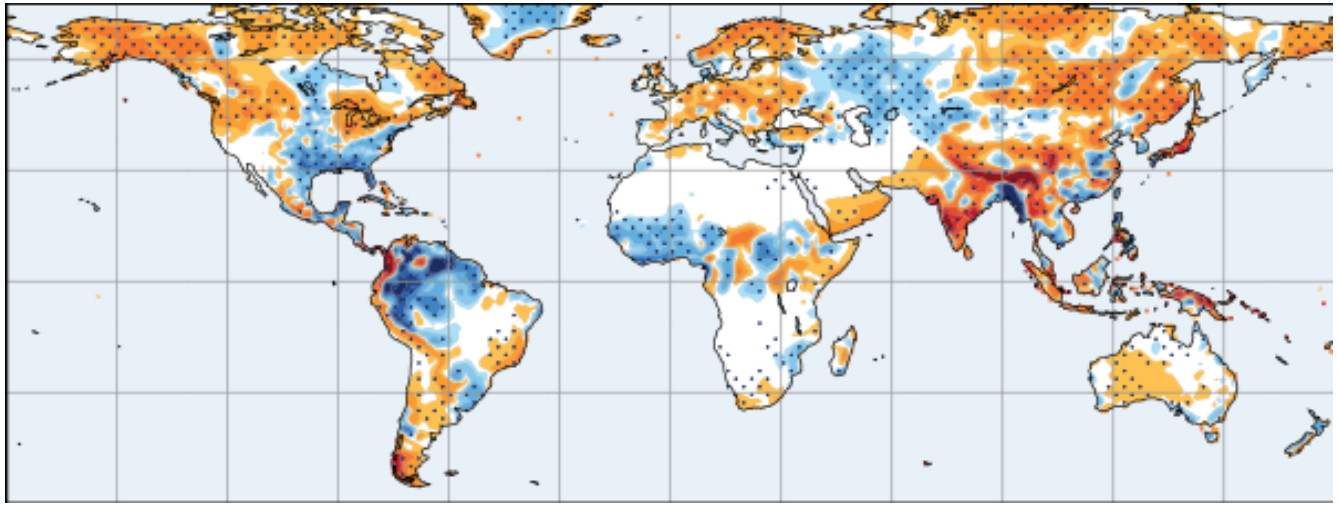
Observed June 2003 Precipitation anomalies (mm/day)



Model Ensemble mean May 2003 T-2m Bias



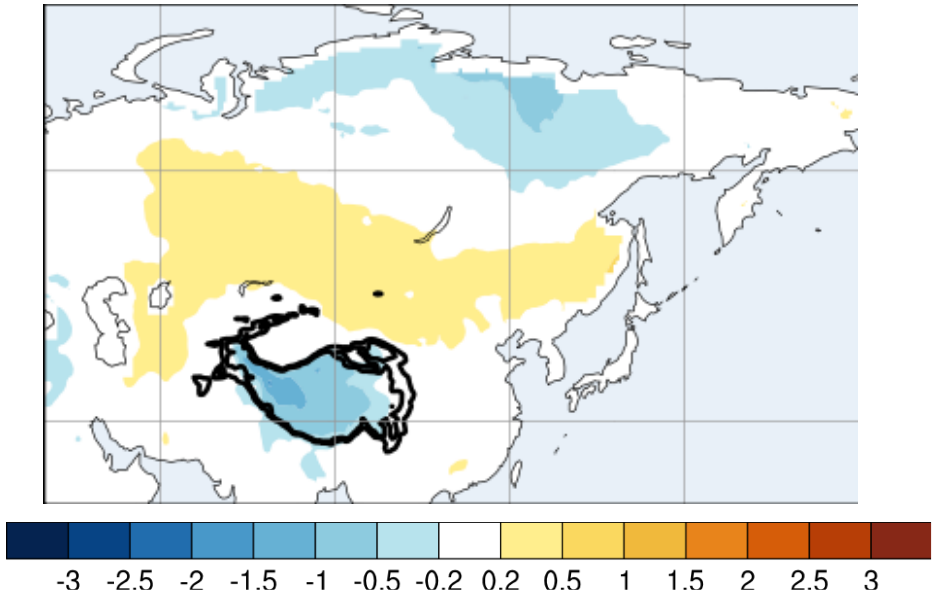
Model ensemble mean June 2003 PRE Bias



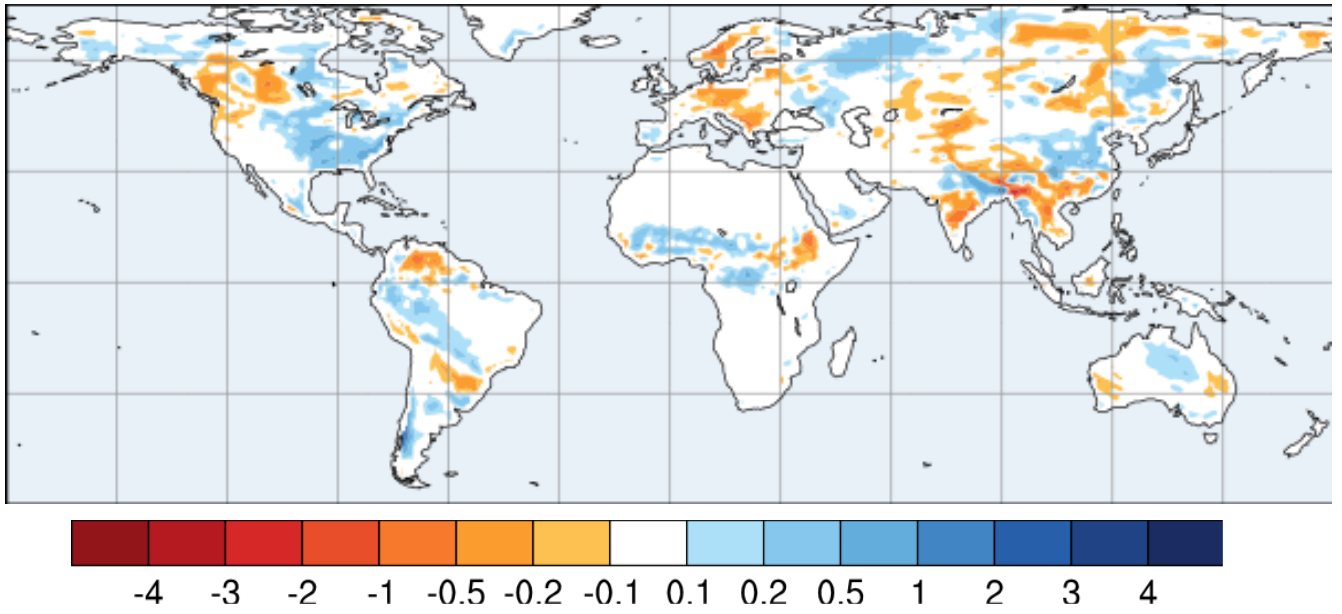
Key Results: LS4P project (impact of init. land temperature and snowpack on S2S)

Eight LS4P model-simulated ensemble mean May 2003 T-2m anomaly and June 2003 precipitation anomaly

Simulated May 2003 T-2m anomalies (°C)



Simulated June 2003 Precipitation anomalies (mm/day)



Key Results: diurnal and sub-diurnal precipitation project

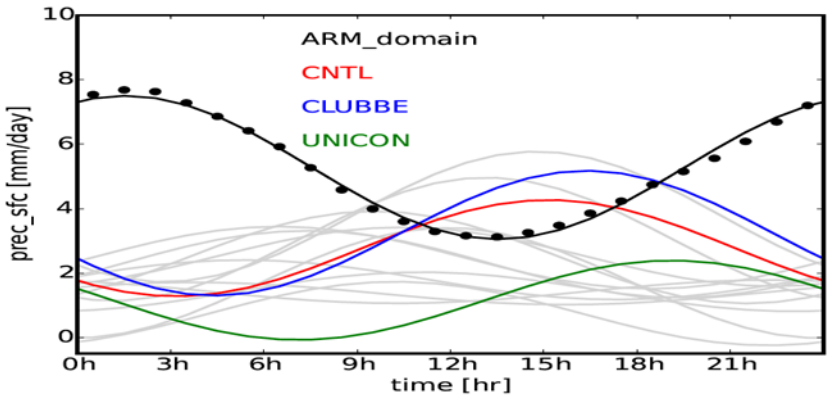
Improving the simulation of the diurnal and sub-diurnal precipitation over different climate regimes:

Goal: to understand what processes control the diurnal and sub-diurnal variation of precipitation over different climate regimes in observations and in models and to identify the deficiencies and missing physics in current GCMs to gain insights for further improving the parameterization of convection in GCMs.

Multiple phases: Interaction between convection and water vapor; Nocturnal convection over land; Diurnal cycle of convection over ocean; Convection transition

Results are being submitted
-> early phase of project. Simulations are ambitious, but results are being submitted

Missing summertime nocturnal precipitation at SGP



GASS Global Atmospheric System Studies

SCM intercomparison cases

Case information

- Long-term (2004-2015) at ARM **SGP** (central US)
- Long-term (2014-2015) at ARM **MAO** (Manaus, Brazil)
- The Midlatitude Continental Convective Clouds Experiment (**MC3E**), 22 April – 6 June 2011. (central US)
- The Plains Elevated Convection at Night (**PECAN**), 1 June – 15 July 2015. (central US)
- The Green Ocean Amazon (**GOAmazon**), IOP1: 15 February – 26 March 2014, IOP2: 1 September – 10 October, 2014. (Manaus, Brazil)

Model setup

- Hindcast run: initiate 00Z every day, take 24-48hr simulations for analysis
- No nudging, 3D advective forcing, prescribed surface fluxes

Participating 10+ SCMs

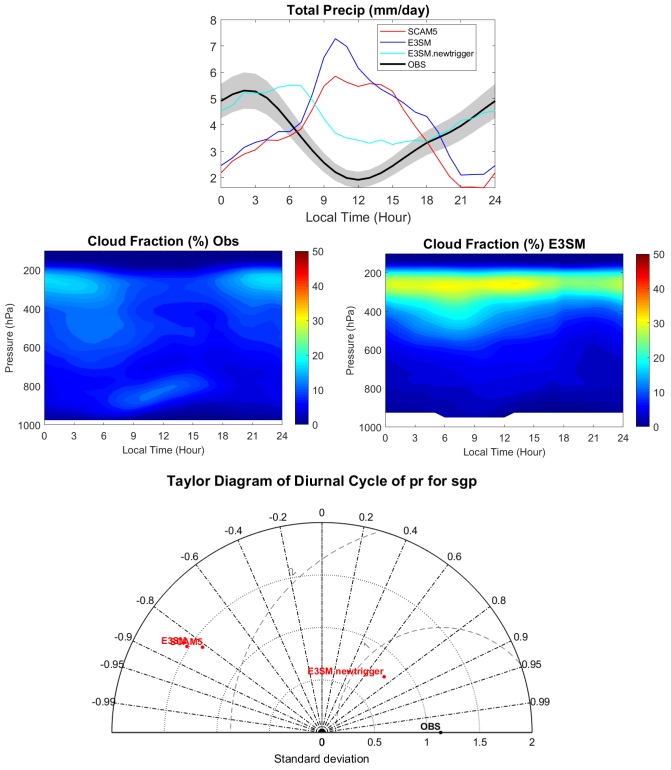
a. TaiESM (Yi-Chi Wang)
b. CAM5 (Shuaiqi Tang)
c. E3SM-SCM (Shaocheng Xie/Shuaiqi Tang)
d. ICON (Daniel Klocke)
e. ECMWF (Peter Bethtold)
f. E3SM-SCM-SILHS (Vince Larson)
g. SAM0-UNICON (Sungsu Park)
h. CMC (Paul Vaillancourt/Jing Yang)
i. DALES-ED(MF)^{n} (Roel Neggers/Philipp Griewank)
j. SP-E3SM (Walter Hannah/Mark Taylor)
k. SCM of the Korean Integrated Model (KIM) (Myung-Seo Koo)
l. SCM of the Brazilian Atmospheric Model (Maybe) (Enver Ramirez-Gutieerez)

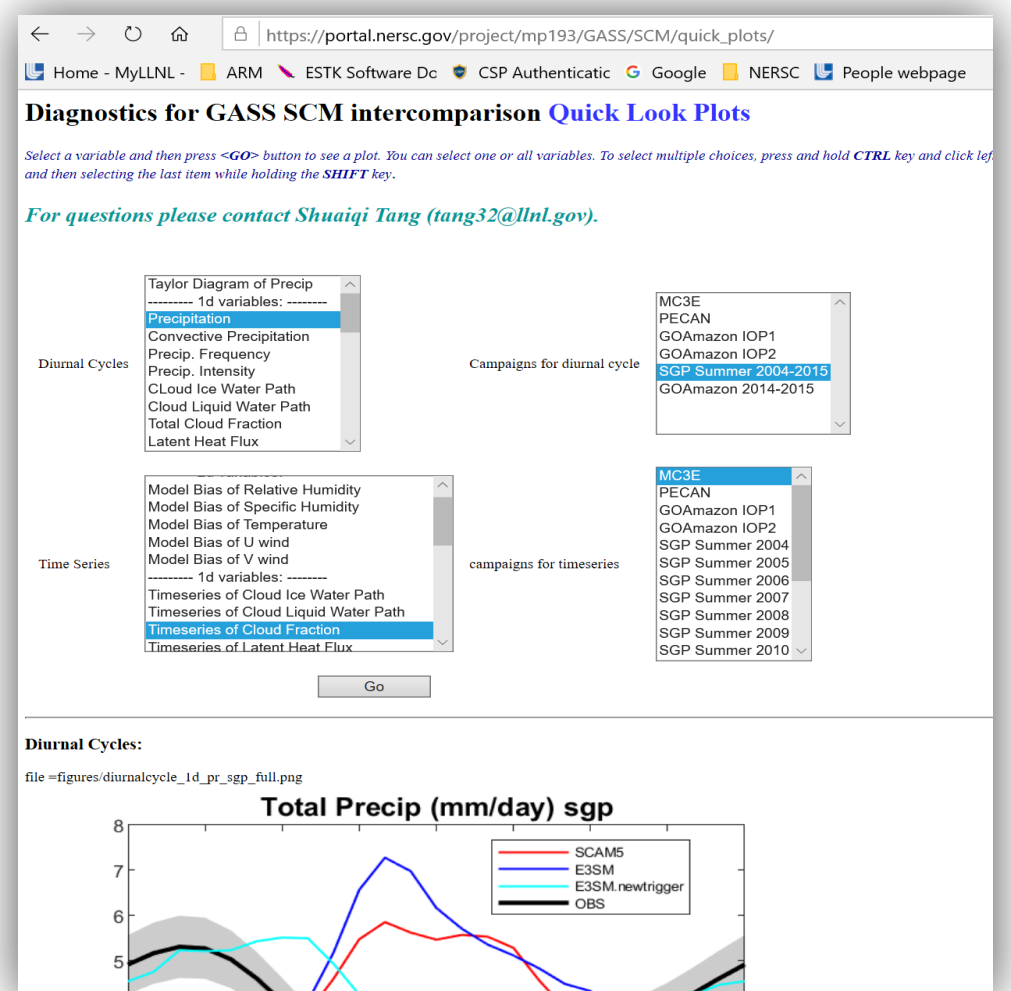
Key Results: diurnal and sub-diurnal precipitation project

Initial diagnostic plots and the interface

Shuaiqi Tang (LLNL)
Shaocheng Xie (LLNL)

SGP (2004-2015 MJJA)





Key Results: UTCC PROES

GEWEX Upper Tropospheric Clouds and Convection Process Evaluation Study (UTCC PROES):

Goal: advance our knowledge of climate feedbacks of UT clouds; therefore gain a better understanding of the interconnection between the convection and the properties of the outflowing anvils. The focus may be widened to the role of cirrus originating from in situ freezing driven by large-scale forcing, via a link to the Stratosphere-troposphere Processes And their Role in Climate (SPARC) Project

Key results:

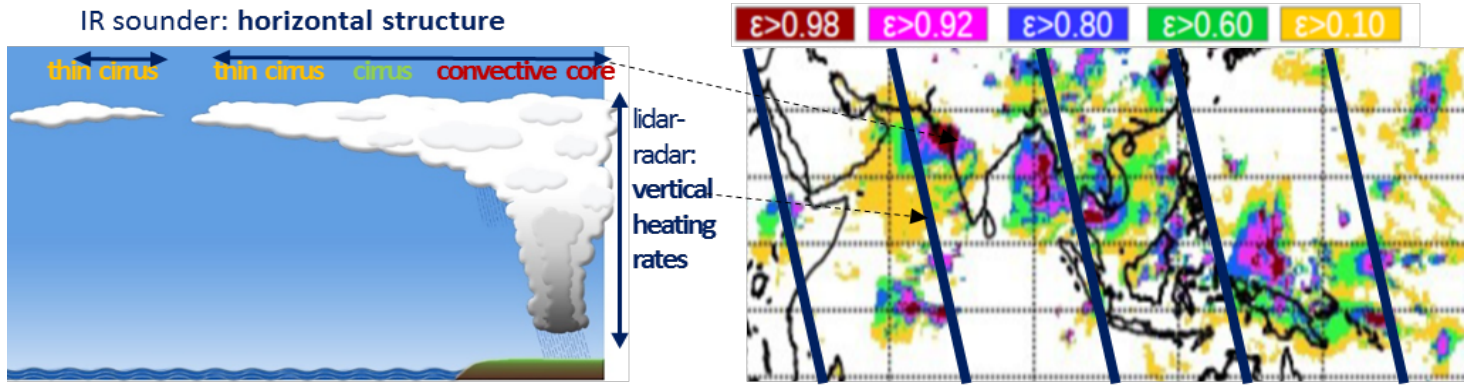
- Cloud System Analysis allows process studies by relating anvil properties to convection & provides new observational metrics to further constrain model parameterizations.

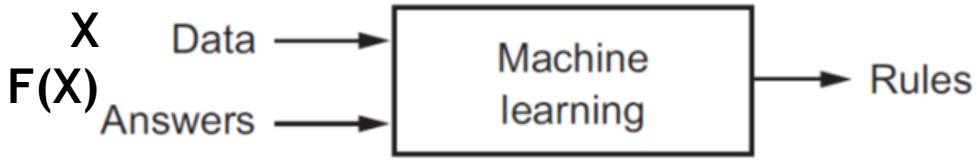
- The emissivity structure of mature convective systems changes with convective depth, with more surrounding thin cirrus

GASS Global Atmospheric System Studies

Key Results: UTCC PROES - towards a 3D description of UT cloud systems

using satellite instrument synergy & deep learning (IA)



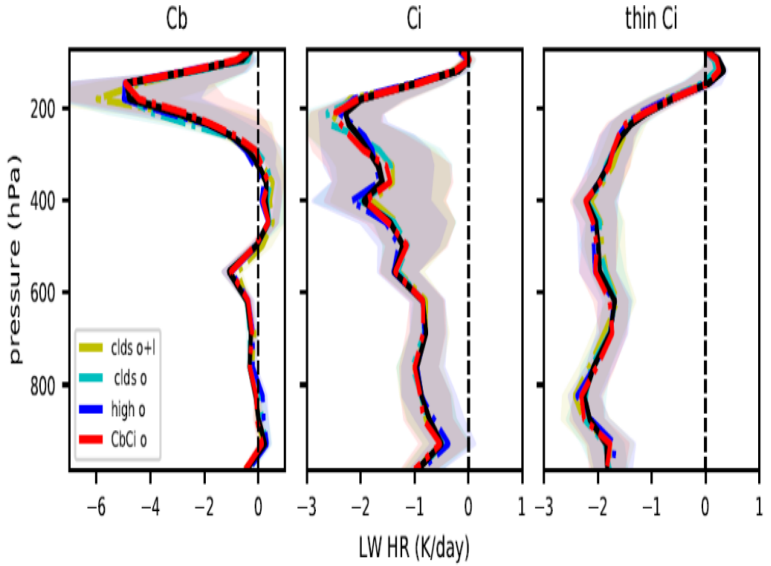


1) develop optimized 'non-linear regression models':
X : most suitable variables (AIRS cloud & ERA atmosphere)
F(X) : vertical structure & heating rates, on tracks (2007-2010)
2) apply models to AIRS-ERA data (2003 – present)
-> extend 3D information for process & climate studies
convection -> radiative heating induced by cirrus anvils
-> large-scale atmos. circulation

ANN models reproduce very well the LW heating rates !

UT cloud systems AIRS: large coverage

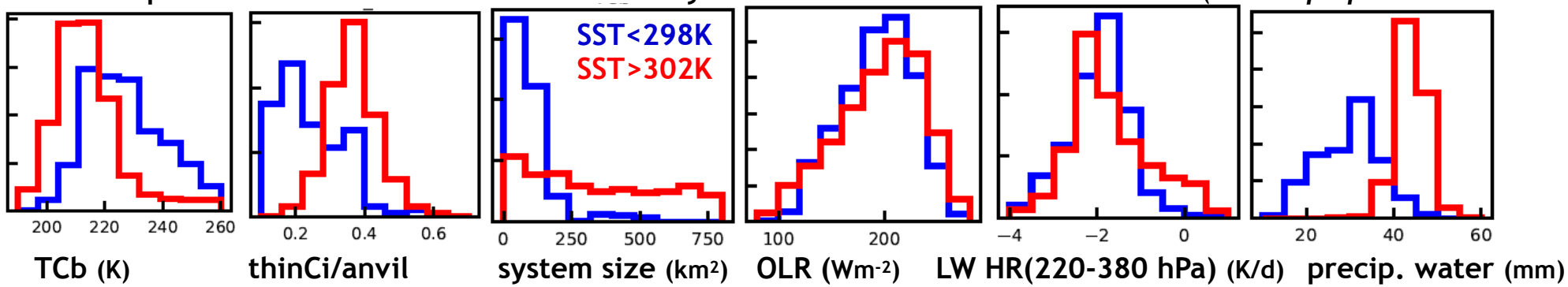
vertical structure CALIPSO-CloudSat: nadir tracks



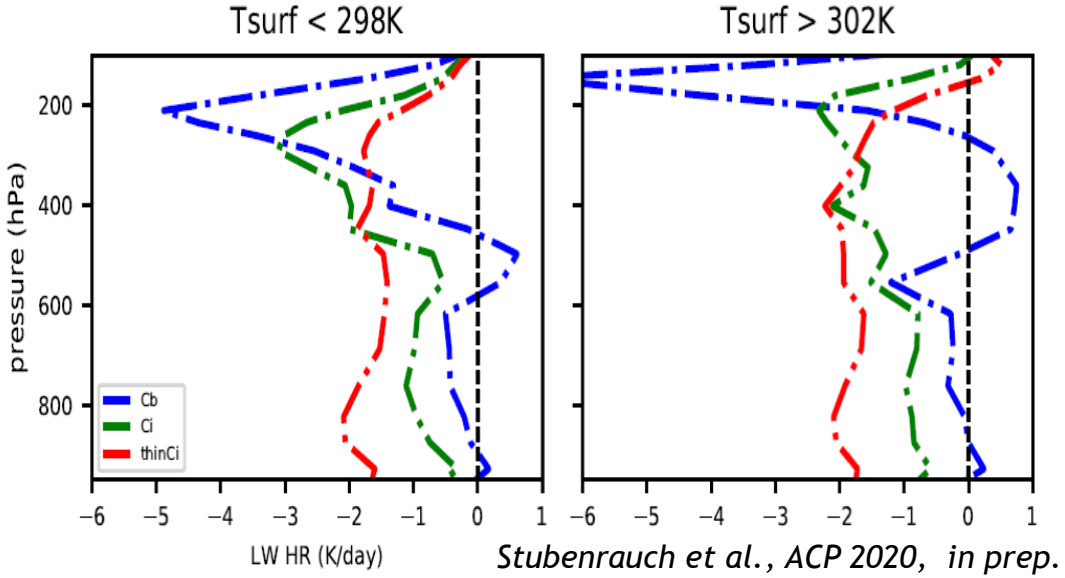
Stubenrauch et al., ACP 2020, in prep.

Example of application: convective cloud systems & SST

2 years of tropical mature convective cloud systems constructed from AIRS *(Protopapadaki et al. 2017)*



Regions of higher SST: more humid with colder, larger convective systems, with more thin Cirrus within anvil (larger OLR) -> larger heating of upper atmosphere
-> affects vertical & horizontal gradients of heating / cooling



Stubenrauch et al., ACP 2020, in prep.

LW heating rates of conv. core, cirrus & thin cirrus anvil of convective cloud systems

synergetic cloud system dataset may be used for process analysis

next UTCC PROES meeting: 9-11 Sep 2020 in New York (just before CFMIP meeting)

Key Results: GABLS-4

GEWEX Atmospheric Boundary Layer Study (GABLS-4):

Goal: study of the interaction between the boundary layer and the surface in strong stability and during the diurnal transition focussing on the decrease of the turbulence

Key results:

- better simulation of the Low Level Jet in many models (compared to the previous GABLS experiment) thanks to a TKE scheme and a height of the first level about 3m.

- For the LES, to reduce the differences or the uncertainties in the LES results it is necessary to use a resolution about 1meter for the horizontal and the vertical directions.

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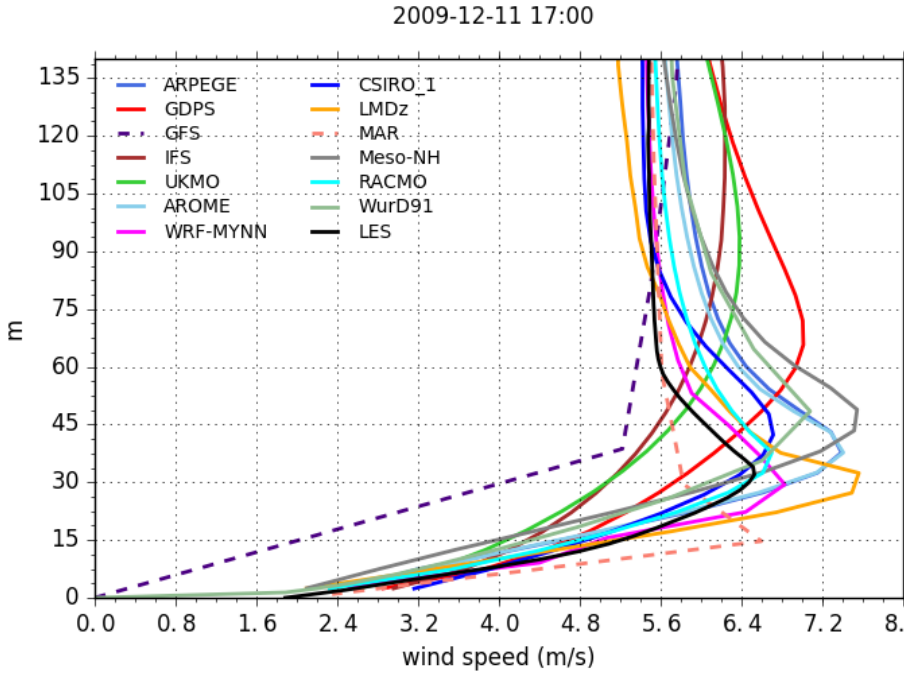
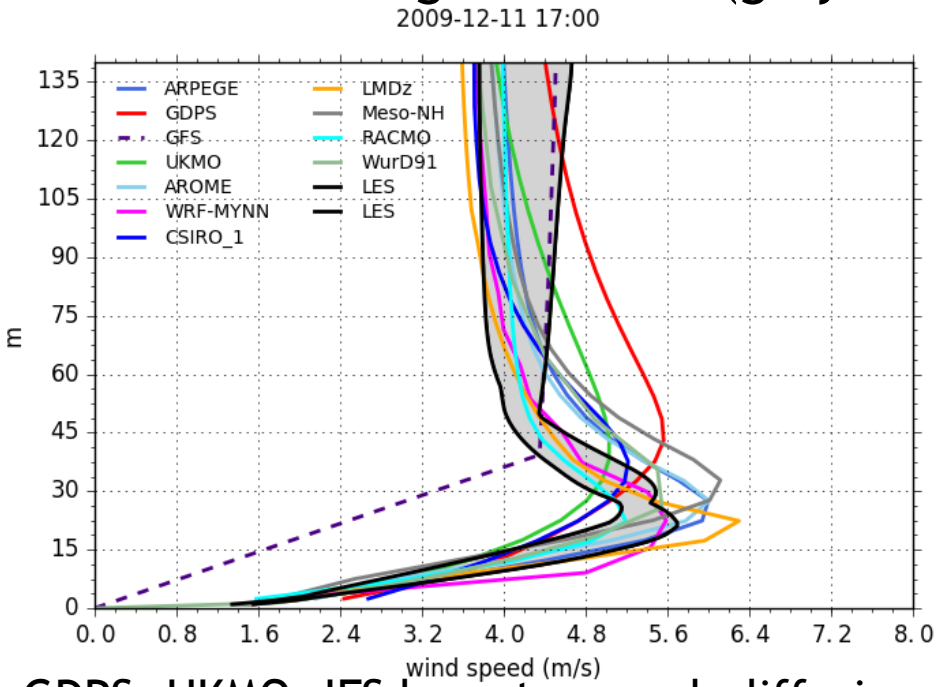
Key Results: GABLS-4 SCM results (Bazile et al. 2020 in prep)

Real case



Ideal case stage 3 all LES (grey area)



Ideal case is representative of the real case. GDPS, UKMO, IFS have too much diffusion with a LLJ too high (in real case and ideal one). All the SCM use the same vertical grid.

The future of GABLS exercise has been discussed during the last GABLS4 workshop in September 2018 and the boundary layer community (observation, LES and NWP) would like to continue with a GABLS5 may be focussed on the polar night.

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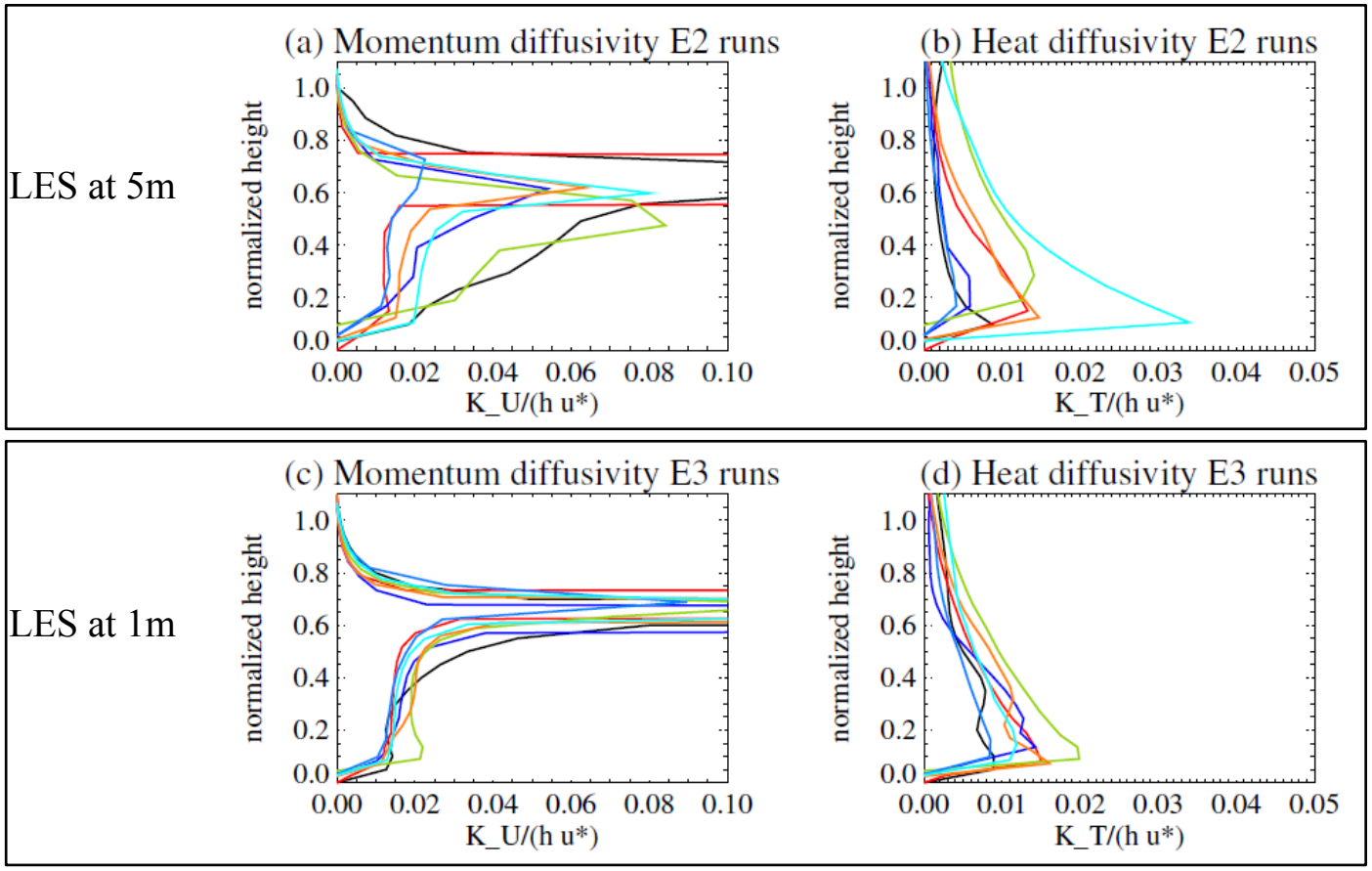
Key Results: GABLS-4 LES results (Couvreux et al. 2020 submitted)

Effective momentum and heat diffusivities normalized by the boundary-layer height at 17h



The spread among the LES is also reduced for such diagnostics thanks to a resolution of 1m

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Key Results: GAP

GEWEX Aerosol Precipitation process study (GAP)

- A review of evidence and scientific consensus for aerosol effects on precipitation through a wide range of proposed mechanisms as been written as a result of a GAP workshop in 2017.

Stier, van den Heever, Christensen, Gryspeerdt, Bollasina, Donner, Emanuel, Ekman, Feingold, Field, Haywood, Kahn, Koren, Kummerow, L'Ecuyer, Lohmann, Ming, Myhre, Quaas, Rosenfeld, Samset, Seifert, Stephens and Tao, 2020: ***The uncertain effects of aerosols on precipitation***. To be submitted to Nature Geosciences.

- A GAP expert workshop on satellite-based assessments of aerosol effects on precipitation was held at Oxford on 23-25 October 2019.

A paper being led by Edward Gryspeerdt, Matthew Christensen and Johannes Muelmenstaedt is now in preparation.

GASS Global Atmospheric System Studies

Key Results: GAP Future activities

- A white paper outlining the role and core goals of GAP is being developed
- Following approval by the GEWEX leadership this will serve as the GAP charter
- Upcoming GAP meetings focused specifically on (1) high resolution modeling and (2) field campaigns are being planned
- An open invitation GAP meeting in 2020 is being considered

Key Results: Partnership

GASS contributed to the development of a position paper of the WCRP modeling groups to the WCRP chairs as well as to a position paper led by WGNE concerning the reorganisation of WCRP modeling activities.

Setting up a survey in collaboration with WGNE to inquire modelling centers about deficiencies in process representations in climate and NWP models.

Reporting to WWRP and linking GEWEX and WWRP activities.

Interacting with the CLIVAR/GEWEX Monsoon Panel on potential collaborations.

Interacting with SPARC on both UTCC PROES and COORDE activities

Future Project: 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

Progress: Discussion of experiment setup at UCP2019 conference in Berlin (Feb 2019), and at the ParaCon convection conference in Exeter (Jul 2019).

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

First test are being made, experiment definition after campaign.
Contact: Rachel Horner
rachel.honnert@meteo.fr

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

Contact: Lorenzo Tomassini
lorenzo.tomassini@metoffice.gov.uk

Future Project: Physics-dynamics coupling

Objective: to improve the understanding and numerical treatment of physics-dynamics coupling in atmospheric models

Leads: Hui Wan and Ben Shipway.

Progress: White paper has been prepared. It is currently under revision that includes four steps:

- Quantify (time-step sensitivity/time-stepping error)
- Attribute (time-step sensitivity/time-stepping error)
- Understand (source of unreasonable sensitivity/error)
- Improve (process coupling)

Timeline: we plan to launch it in 2020.

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Direction of future GASS projects

Under consideration:
Stable boundary layer (follow-up on GABLS3/4); e.g. around the MOSAiC campaign over the Arctic– under discussion

After the EUREC4A campaign, a project on convective momentum transport is being envisaged following COORDE.

An analysis of diurnal cycle of precipitation simulated by CMIP6 models is being planned as part of DCP. This work will be done by collaborated with scientists in PCMDI.

Potential gaps:
- Joint effort on the surface flux project of WGNE along with other programs
- ACPC partnership: One mechanism is through the GEWEX Aerosol Precipitation (GAP) initiative. How do we incorporate GAP activities into GASS?
- 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.
- Machine learning in model parameterization development?

GASS Global Atmospheric System Studies

Contributions to GEWEX Science Questions

Observations and Predictions of Precipitation

- Three existing GASS projects directly address precipitation: the precipitation diurnal cycle, LS4P, and GAP
- Two projects to be launched in 2020 will also address precipitation: the gray zone project and the physics-dynamics coupling project.

Global Water Resource Systems

- One GASS project (LS4P) is directly related to the global water resources systems.

Changes in Extremes

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

Water and Energy Cycles

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

GASS Global Atmospheric System Studies

Plan for Next Year

Work with existing project leaders to reach their yearly goals

Launch the grey-zone II project and Dynamics-Physics Coupling project

Develop panel by adding one YESS member and one other member

Plan pan-GASS conference for 2021

Develop the questionaire to survey climate and NWP modelling centres about their priorities in addressing deficiencies in represented process.

CFMIP and GASS collaborated on the CGILS project (CFMIP-GASS Intercomparison of LES and SCMs); Discussion ongoing on a potential joint project (next CFMIP meeting in Sep 2020 in Seattle, Washington).

GASS Global Atmospheric System Studies

Questions for SSG

Organizational for PROES

- UTCC and GAP are part of GASS, and UTCC also reports to GDAP. GAP report is missing.
- should their leaders be GASS Panel members?

GASS membership

- currently GASS Panel members (**eight**): two co-chairs, four members leading the four GASS projects, two members representing grand challenge and early-career scientist
- Potential new members (**five**): will add one more YESS member; May add PROES leads as members (2); Will add leads of new projects as members (2)
- Should we consider additional expansion of GASS membership?

GASS partnership with other programs

- GASS already has close interactions with WGNE and WWRP and some other programs. Should the interaction with WWRP be consolidated?
- Are these interactions appropriate for GASS (e.g., considering the re-organization of WCRP)?