GASS project proposal: LES & NWP fog modelling intercomparison

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Most operational NWP centres will list errors in fog forecasting amongst their top model problems, with high priority requirements for improveement. The key customer driving this is the aviation sector, with ~40% of all delays (~50% of weather related delays) at busy airports (such as London Heathrow) being due to low visibility events. Despite this importance, there is no international community working together on improving fog modelling. A new GASS project related to fog modelling therefore presents an opportunity to form a community to address the challenges together.

A growing collaboration between the Met Office, Meteo France, and FMI has been established, utilising observational data collected as part of the Local and Non-local Fog Experiment (LANFEX), conducted in the UK from 2014-2016. The 1st intensive observational period (IOP1) presented a relatively simple case of fog forming in a nocturnal stable boundary layer, developing over several hours into turbulent, optically-thick fog. However, NWP modelling of this event (Boutle et al. 2017, ACP) showed significant errors in the structure and evolution of the fog.

Therefore, we are planning an LES & NWP model intercomparison of this case. Participants and an initial outline of the case is presented below, and we are keen to hear from any other centres who wish to be involved. Key questions to be answered include:

- 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?

There is plenty of scope for participants to shape the direction of the project as it evolves. The initial phase of work should lead to some interesting publications documenting the current state of LES & NWP fog modelling within the community, and opportunities for improvements applicable to many models. Further stages will then be determined by earlier results, but LANFEX contains 19 IOPs which are well observed, and Meteo France are planning a similar observational campaign in 2019, which could provide an alternative set of observations against which to compare the models. Fogs are also important in the climate system, but their representation in climate models has rarely been looked at in the literature. Therefore future stages of this project could investigate how well represented they are in CMIP-style models, and suggest key improvements to future climate models.

The project will be lead by Ian Boutle, who along with the listed co-chairs, have experience in LES and NWP modelling of fog, the available observations with which to constrain the models, and the model parametrizations to be improved. In many ways this project builds on previous work conducted under GABLS & GCSS/GASS, which has generated a wealth of knowledge on stable boundary layer & cloud microphysics modelling, which can be brought together here to tackle this particularly challenging issue.

Case participants

Institute	NWP	LES	PIs
Met Office	Met Office Unified Model (UM)	Met Office NERC Cloud Model (MONC)	Ian Boutle Adrian Hill
Meteo France	AROME	Meso-NH	Christine Lac Thierry Bergot Benoit Vie
FMI	HARMONIE-AROME	UCLA-SALSA	Sami Romakkaniemi
Wageningen University	WRF		Gert-Jan Steeneveld
Hannover University		PALM	Bjorn Maronga
DWD	ICON	ICON-LES	Tobias Goecke

Case details

The philosophy of the current proposal is to build up in complexity from the simplest case first. It is therefore broken into 3 sequential stages.

Stage 1:

- Models initialised from a radiosonde profile and forced by surface temperature throughout. No other forcing is required. Either initial aerosol or cloud droplet number concentrations will be specified, depending on the model microphysical parametrization.
- LES models to be run at ~4m resolution (possibly higher).
- NWP models to be run in single-column (SCM) mode, with vertical resolution of the native NWP model.
- Provides a baseline on the current level of agreement between LES & SCM models – which may well be very low!
- Sensitivity tests adjusting various aspects of the model parametrizations to improve agreement with observations if initial agreement is poor.

Stage 2:

- Using the best setup from stage 1, replace surface temperature forcing with interactive land surface model & repeat analysis.
- Most important for the NWP models (still being run in SCM mode), but also interesting for LES models with interactive land-surface capabilities.

Stage 3:

- Using the best setup from stage 2, run the NWP models in 3D forecast-mode, at a range of resolutions from 1km to 100m.
- To be decided whether this will be initialised from an analysis with forced LBCs, or idealised profiles with bicyclic LBCs.
- Most important for the NWP models, but also interesting for LES models that can be run at this range of resolutions.