Automated Large Eddy Simulations over land with coupled LSM

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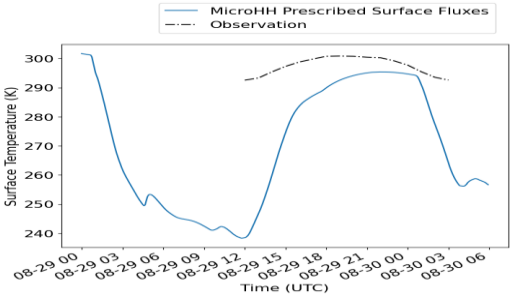
Large Eddy Simulations – With Integrated Land-Surface Modelling

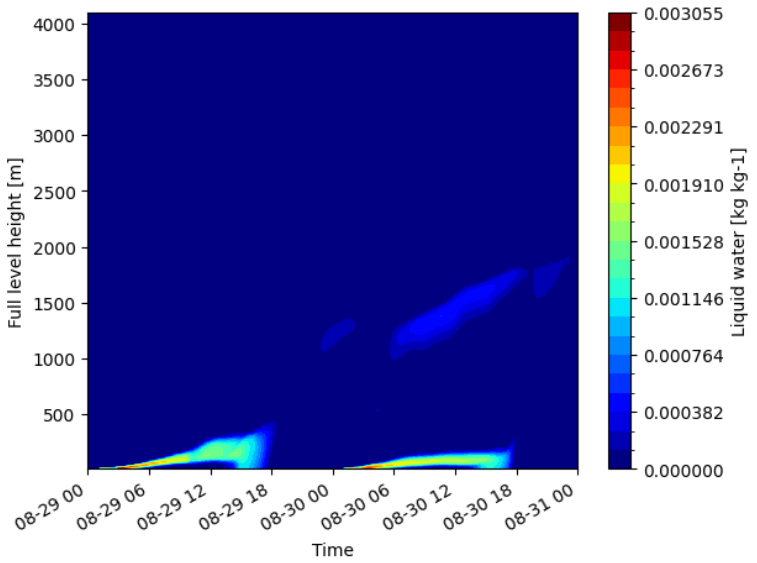
Motivation

- Automated LES model running continuous simulations with a start date over land-domain (SGP and BNF)
- Model with prescribed surface fluxes produces a dense nighttime fog layer resulting in surface decoupling.

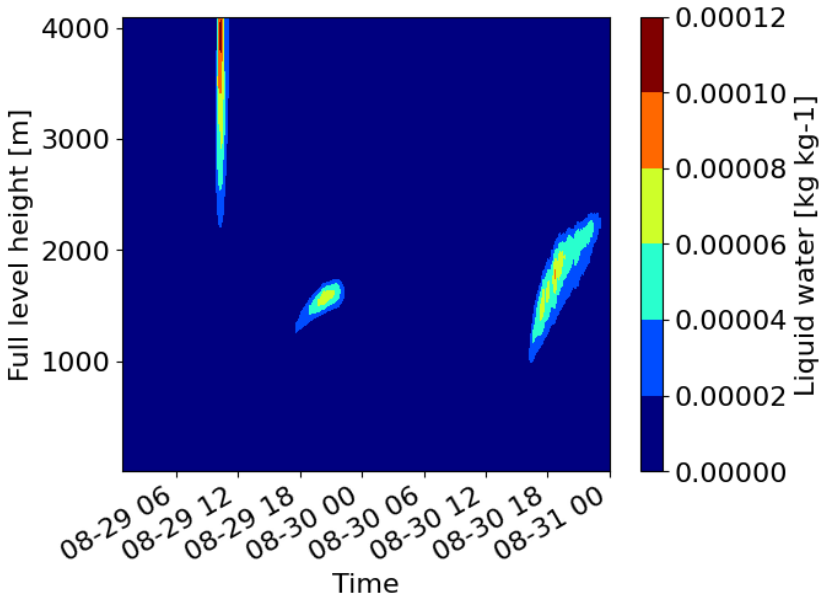


Goal

- Setup a generic LSM-coupled LES model that allows for a continuous run.
- Evaluate model performance with observations over ARM-SGP site and LASSO LES simulations.



29th August 2015
With prescribed Surface Flux



With Coupled LSM

LES-LSM Model Setup and SGP Comparison Plots

Initialized: September 21st, 2017; Run-time: ~4.5 days

LES Model

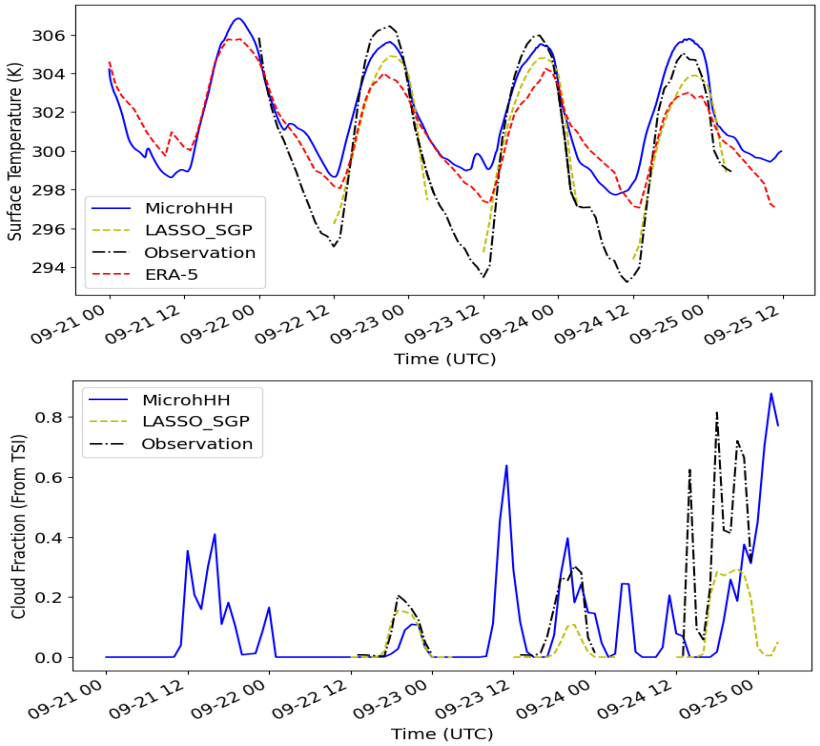
- MicroHH LES code with interactive radiation scheme (RRTMGP)
- Initial condition and Large Scale Forcing – **ECMWF-ERA5** (114km Forcing Scale)

Soil Model

- Land Surface Model derived from HTESSEL scheme by ECMWF
- **Homogeneous Soil Model** over model domain
- Initial Soil Water Vapor, Soil Temperature profiles from ERA5
- Vegetation Parameters (LAI, Minimum Vegetation Resistance, Roughness Length etc.) based on type of vegetation over the domain

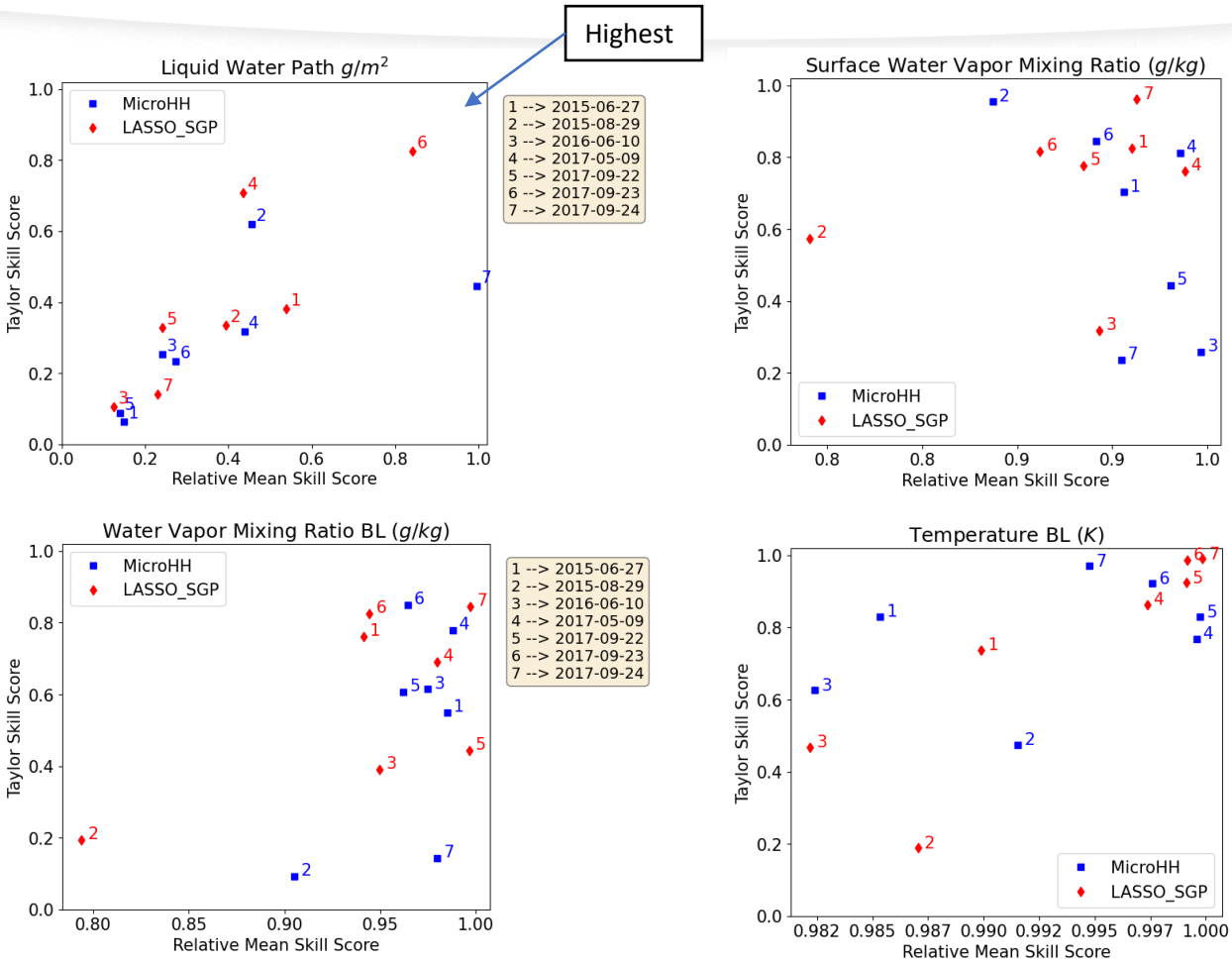
SGP/BNF Simulations

- Output domain size – **25.6 km**, Resolution – **100 m** (Δx, Δy) and 10-20m (Δz), Spin-up Time ~ 1-day, No Nudging
- Comparison with LASSO-SGP (simulation-2: 25.0 km, 100m, VARANAL Surface Treatment and Large Scale Forcing with 300 km forcing scale)



- Surface Temperature shows good agreement with model without any runoff for ~5-day simulation.
- Captures the onset of daytime shallow cumulus connection well compared to observation.

Comparison with LASSO – Taylor and Relative Mean Skill Scores



Taylor Skill Score → Measure time series variation

Relative Mean Skill Score → Measures difference in time averaged mean

7 SGP Days

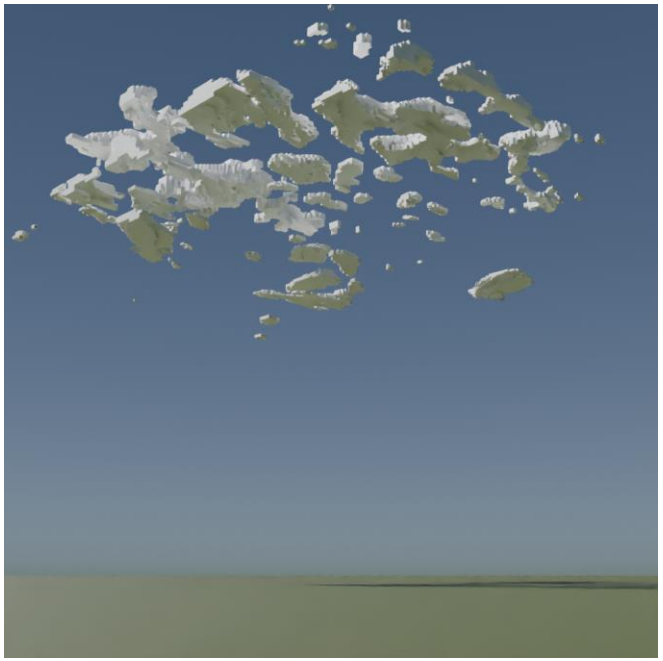
Red → LASSO

Blue → LES-LSM

Boundary Layer --> 500m to 700m AGL

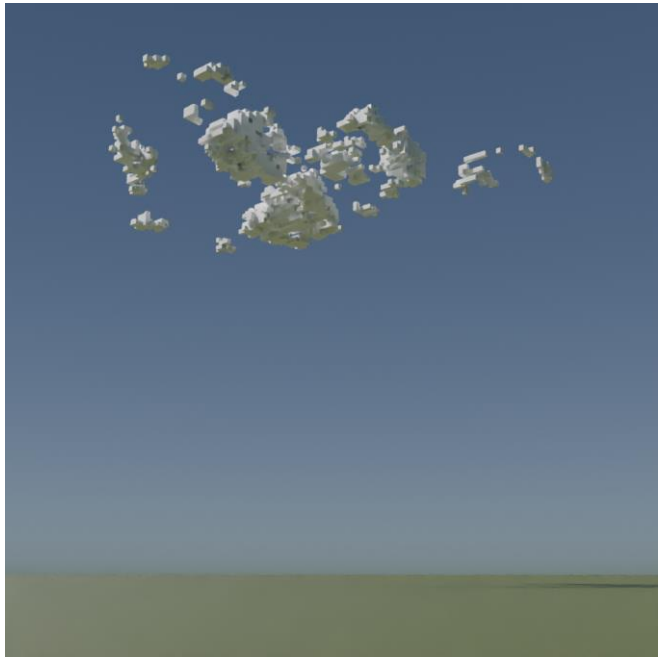
Comparison against Stereo Camera Data and Summary

- **User friendly** Automated LES-LSM Model to perform Land-based LES simulation with specified time, duration and location.
- **Runs continuously** over shallow cumulus days without runaway.
- GPU based model runs a lot faster (256*256 grid simulation – 3 days ~ 6 hours)
- Model performs well during SGP days in comparison to ground observations.
- Model cloud field visualization using Blender shows good agreement with on field COGS Stereo Camera observation.
- To be installed on the **ARM-Cumulus** supercomputer to perform high-resolution simulations over Bankhead National Forest.



LES-LSM Model

14th May 2019, 11:30 am CT



COGS Stereo Camera Data

*Burchart et al. ***A Stereo Camera Simulator for Large-Eddy Simulations of Continental Shallow Cumulus clouds based on three-dimensional Path-Tracing***. ESS Open Archive . June 23, 2023.