A Rescope of the MODAL Project for Financial Year 2017

Background

Models to Observations, a Digital Atmospheric Library (MODAL) is an Argonne Strategic Initiative aimed at building better observations of the earth through the use of designing integrated field laboratories using LES models and instrument simulators.

The project has two distinct parts: A set well documented library of atmospheric scenes and a software repository containing instrument simulators that produce ARM-like instrument data streams from the atmospheric scenes.

Progress in Financial Year 2016

We made substantial progress since the project was funded despite difficulties in hiring a postdoctoral staff member. We ran our first set of LES simulations using forcing data from the RICO campaign [1]. We designed a simple simulator for a scanning cloud radar and set this up to do simple conical scans of the atmospheric scene generated by the LES data.

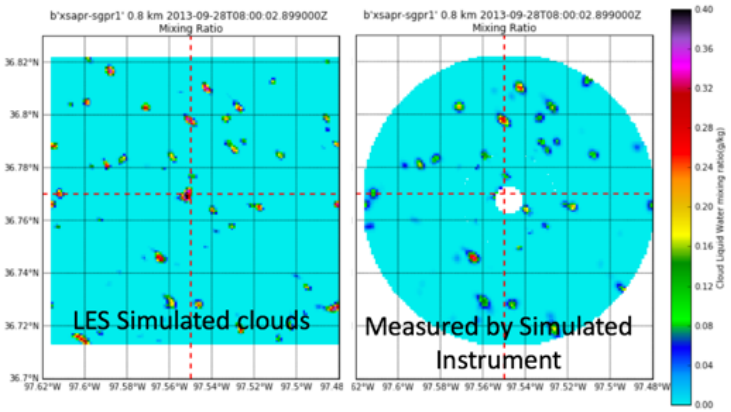

Figure 1: As example of LES Simulated clouds and radar sampled then re-gridded clouds.

Figure 1 shows modelled cloud liquid water content from WRF-LES on the left and a retrieved cloud field from a conically scanning cloud radar on the right.

Figure 2 shows the increasing error in retrieved cloud fraction as a function of height and also as a function of the number of nested cones.

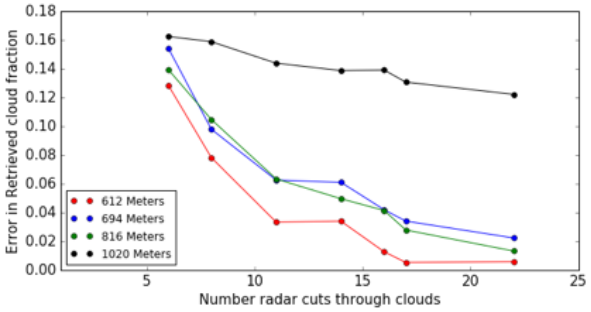

Figure 2: Error in cloud fraction as a function of height in the model domain and number of elevation angles in a conical scanning pattern.

This initial work has allowed us to investigate the errors in retrieved cloud fraction due to under-sampling and is an early demonstration of the potential of MODAL.

Plan for Financial Year 2017

First, in 2017 we will be expanding the number of instruments simulated. We will be slightly reducing the number of planned instruments to ensure success specifically aiming at the suite of instruments that support the ARM flagship product: Actively Remotely Sensed Cloud Layers, ARSCL [2]. These are: The vertically pointing Cloud Radar, Microwave Radiometer and micropulse LIDAR. The last two are mentored by Argonne scientists.

We will engineer these simulators and couple them to the model data in such a way they are re-usable and become a strategic asset to Argonne that we can use to build the beginnings of an ARM Virtual Facility (AVF).

Since many papers develop cloud climatologies from ARSCL we can use MODAL to investigate the impact of the local environment on clouds retrieved using the simulator. Using a model to generate our cloud scenes allows us to "turn on and off" the local environment. There are two specific examples we will explore:

1) The impact of surface heterogeneity at the Southern Great Plains. We will download data from ARM's LASSO project and use this to force LES using observations with and without the effect of land surface heterogeneity (ie the "patchwork" of crops around the site).

2) The impact of flow over terrain on radar cloud climatologies. We will model open oceanic clouds near ARMs Eastern North Atlantic site with and without the island it is located on to see if the clouds measured are truly representative of the open ocean.

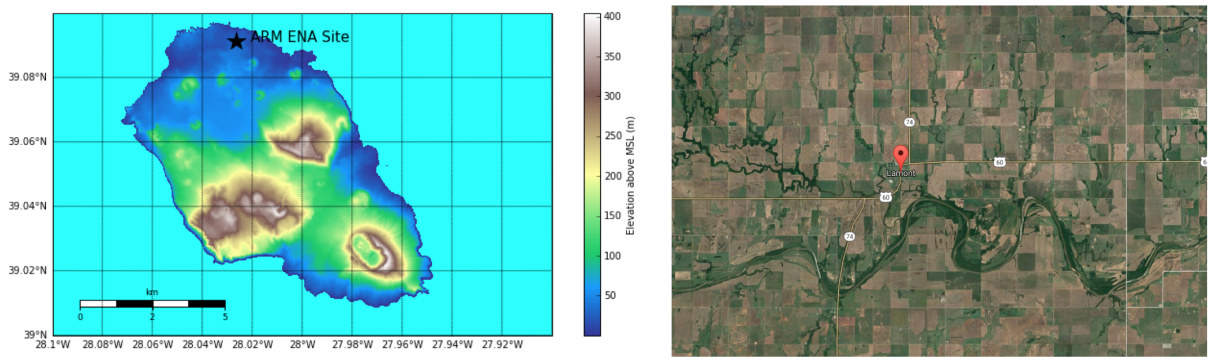

Figure 4: Left: Terrain of Graciosa Island in the Azores, Eastern North Atlantic. Note the small size ofthe island. Right: Aerial image of the landscape around the ARM Southern Great Plains Site. Note the patchwork of crops which lead to differing moisture fluxes which generate clouds.

Software Engineering and Sustainable Science

All code and results will be version controlled and hosted on a private GitHub repository and after we have published results and the code is in a mature, tested, state we will release open source. While the framework will not be as sophisticated as we originally proposed it will be useful to collaborators and able to be used as a tool by DoE for understanding how instrument parameters and local terrain and land use impact measurements and retrievals of cloud and other properties.

References

[1] Robert M. Rauber, Harry T. Ochs III, L. Di Girolamo, S. Göke, E. Snodgrass, Bjorn Stevens, Charles Knight, J. B. Jensen, D. H. Lenschow, R. A. Rilling, D. C. Rogers, J. L. Stith, B. A. Albrecht, P. Zuidema, A. M. Blyth, C. W. Fairall, W. A. Brewer, S. Tucker, S. G. Lasher-Trapp, O. L. Mayol-Bracero, G. Vali, B. Geerts, J. R. Anderson, B. A. Baker, R. P. Lawson, A. R. Bandy, D. C. Thornton, E. Burnet, J-L. Brenguier, L. Gomes, P. R. A. Brown, P. Chuang, W. R. Cotton, H. Gerber, B. G. Heikes, J. G. Hudson, P. Kollias, S. K. Krueger, L. Nuijens, D. W. O'Sullivan, A. P. Siebesma, and C. H. Twohy, 2007: Rain in Shallow Cumulus Over the Ocean: The RICO Campaign. Bull. Amer. Meteor. Soc., 88, 1912–1928, doi: 10.1175/BAMS-88-12-1912.

[2] http://www.arm.gov/publications/tech_reports/arm-vap-002-1.pdf?id=138

[2] Hipólito, A., Madeira, J., Carmo, R. and Gaspar, J.L. (2013) Neotectonics of Graciosa Island (Azores): a contribution to seismic hazard assessment of a volcanic area in a complex geodynamic setting. Annals of Geophysics 56 (6), S0677.