Houston Case Study Specifications using WRF and RAMS

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Model Setup and Experiment Design tested extensively by Peter Marinescu (CSU) and Bethan White (Oxford)

ACPC Website

- www.acpcinitiative.org
- Documents to be posted – Peter Marinescu
- ACPC meeting in Oxford (April 2016) => DCC roadmap developed
- Appendix of DCC roadmap has recommended CRM setups

ACPC DCC Initiative

Goals

1. to increase our understanding of the impacts of aerosols on deep convective storms, and
2. to enhance the representation of these impacts in cloud-resolving models (CRMs) through global climate models (GCMs)

through the utilization of a unique combination of observations and numerical experiments.

Key Science Questions

- SQ1: What is the variability of the atmospheric response, both locally and regionally, to aerosol perturbations among different state-of-the-art CRMs?
- SQ2: What physical processes are the most significant contributors to aerosol-induced uncertainties in current CRMs, in terms of representing aerosol-cloud-precipitation-climate interactions?
- SQ3: What are the spatial and temporal observations required to calculate accurate estimates of energy, moisture, and aerosol fluxes on the scales of a GCM grid box?

Approach

- **Part I: Multi-Model Case Study Simulations**
- **Part II: Observational Analysis**
- **Part III: Box Closure Study**

Approach

Part I: Multi-Model Case Study Simulations

- Case study focuses on isolated deep convection near Houston, Texas on 19-20 June, 2013
- Favorable due to:
  - Isolated nature of deep convection
  - Localized sources of aerosol particles evident
- Ensemble of different CRM case study simulations with clean and polluted conditions will be evaluated using observations

Approach

Part I: Multi-Model Case Study Simulations

- The simulations will be used to quantify the spread in the response to aerosol perturbations among the range of state-of-the-art CRMs => SQ1
- In-depth analysis of individual convective cells and microphysical processes (together with observational analysis) will provide the physical reasons for these results => SQ2
- Extensive model testing with WRF and RAMS to assess appropriate simulation setups

Model Configuration

Model configuration	Setup
Simulation period	1200 UTC 19 June 2013 to 1500 UTC 20 June 2013
Total run hours	27
Initialisation and boundary data	NCEP Global Data Assimilation System (GDAS)/FNL ***(download link)***
Number of model nests	3, one-way nesting only (no interactive nests), all nests share same centre lat / lon
Horizontal grid length of each nest	4.5km, 1.5km, 500m
Number of horizontal grid points in each nest (Approximate size of each nest)	4.5km nest: 400 x 400 grid points (~1800 x 1800 km), 1.5km nest: 547 x 547 grid points (~820 x 820 km), 500m nest: 703 x 703 grid points (~350 x 350 km) (or closest numbers of grid points that your model will allow)
Vertical levels	95, please use the level spacings (in either height or pressure) specified at this link
Model top	Approx. 22km / 50hPa; please use provided specified levels
Centre lat of domain	29.4719
Centre lon of domain	-95.0792
Map projection	Lambert preferred, otherwise use best option for your model
Geographical / topography data	Please use highest resolution data available
Coriolis	On
Model time step, outer nest	6 s
Time step ratio per nest	1:3
Frequency of radiation calling	10 minutes
Frequency of model output (each nest)	4.5km nest: 60 minutes for entire simulation 1.5km nest: 60 minutes for entire simulation 500m nest: 60 minutes for entire simulation, 5 minutes between [1600 UTC 19 June and 0400 UTC 20 June 2013], and 1 minute between [2000 UTC 19 June and 0000 UTC 20 June 2013].

Physics Parameterizations

Physics parameterisations	Setup
Land-Surface model	Please use an interactive land-surface model if available
Convection	No convection or cumulus scheme in any of the 3 grids
Cloud Microphysics	Two-moment bulk or bin scheme preferable, interactive aerosol processing optional. Please use specified initial aerosol profiles below
Aerosol - radiation coupling	Radiatively inactive aerosols
Diffusion / PBL	Please use best option for your model; please call every time step
LW radiation	Please use best option for your model; please call every 10 minutes
SW radiation	Please use best option for your model; please call every 10 minutes

Aerosol Experiments

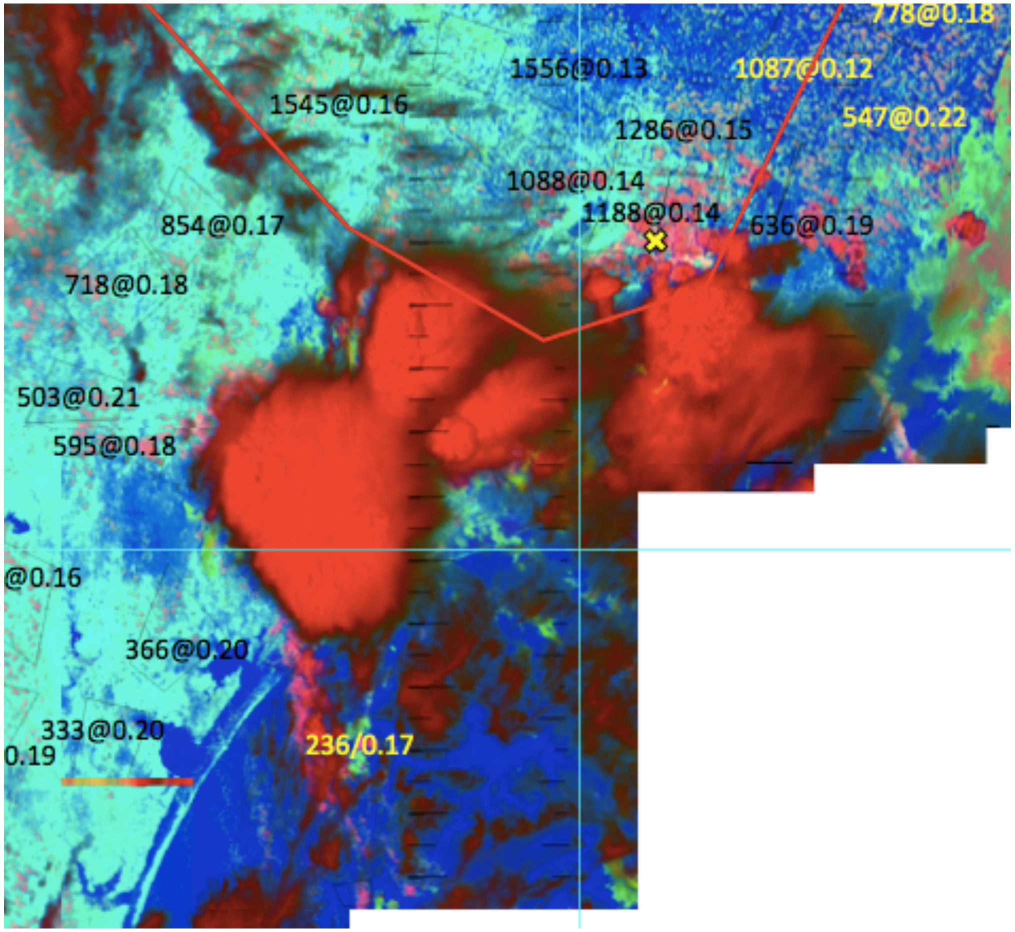
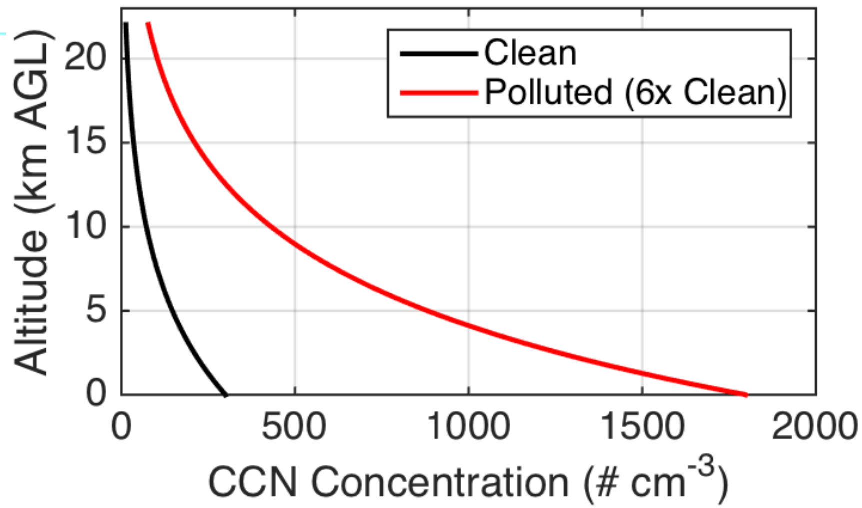


Image provided by Daniel Rosenfeld

- 2 Experiments => 1 clean and 1 polluted
- Clean: AP(z) = 300 cm^{-3} * exp(z/7000m)
- Polluted: AP(z) = 1800 cm^{-3} * exp(z/7000m)



These aerosol values are based on convective cloud base cloud droplet number concentrations estimated via a satellite algorithm from data on 19 June 2013 case. Details of this algorithm can be found in Rosenfeld et al. (2014).

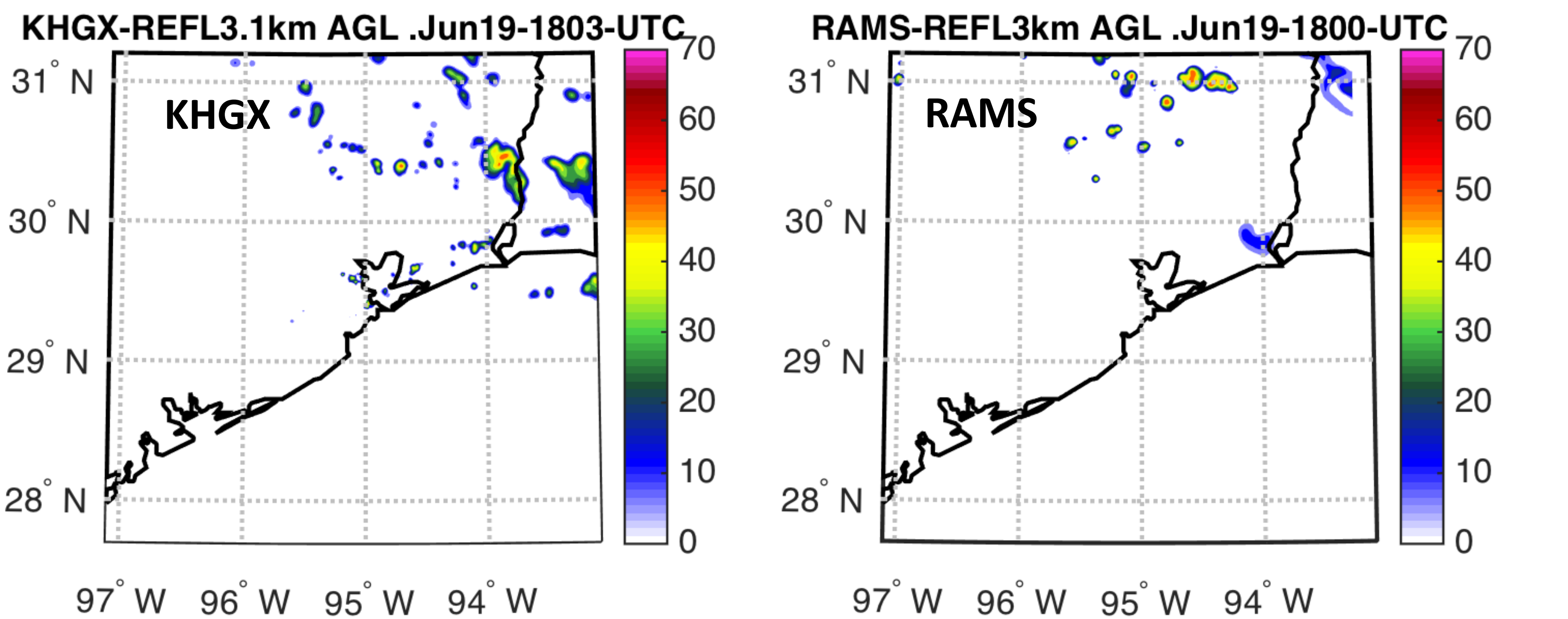
Model Outputs

- Specific model outputs are requested
- The simulation data will be archived within an ACPC workspace on JASMIN, a data center funded by the Natural Environment Research Council (NERC) and the UK Space Agency (UKSA).
- Various frequencies and formats required

Comparisons to Observations

June 19, 2013

- 3KM AGL Radar Reflectivity: 1800 UTC



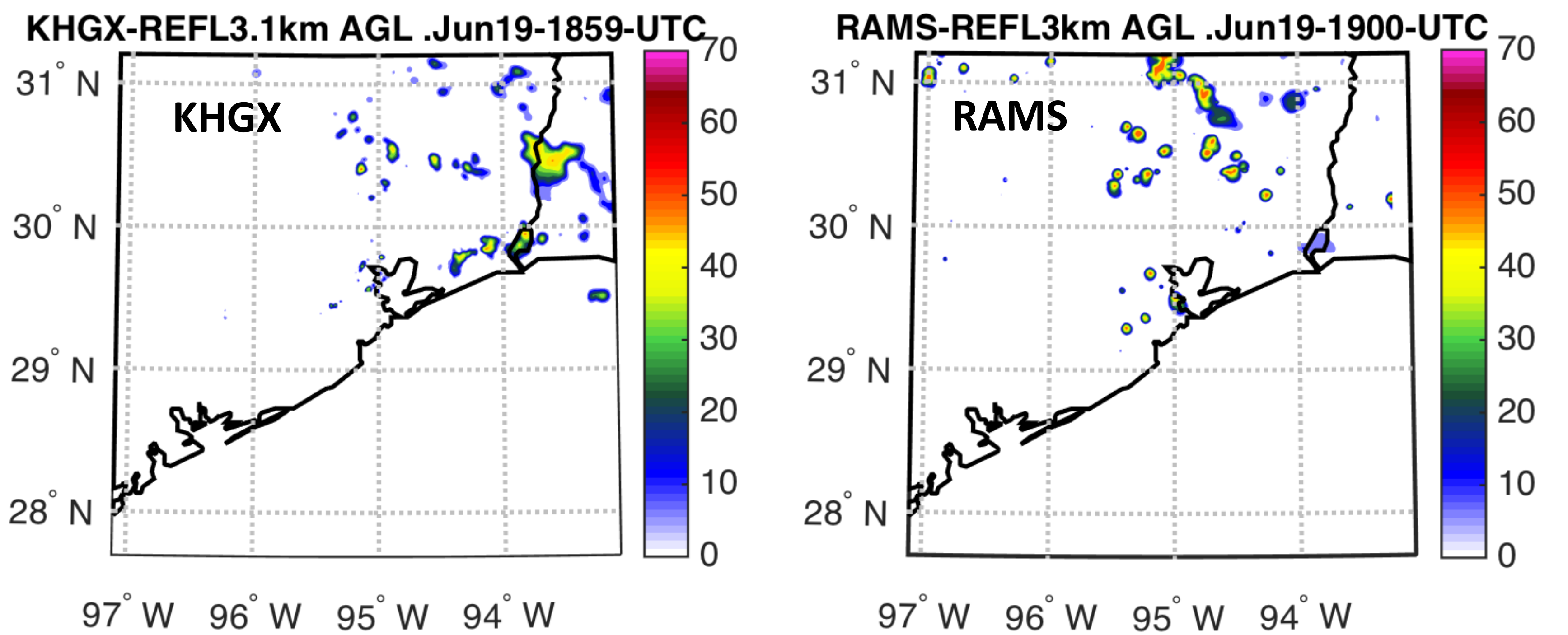
Scattered convective cells develop in north-western Texas

KHGX radar data provided by Marcus van Lier-Walqui and Ann Fridlind

Comparisons to Observations

June 19, 2013

- 3KM AGL Radar Reflectivity: 1900 UTC



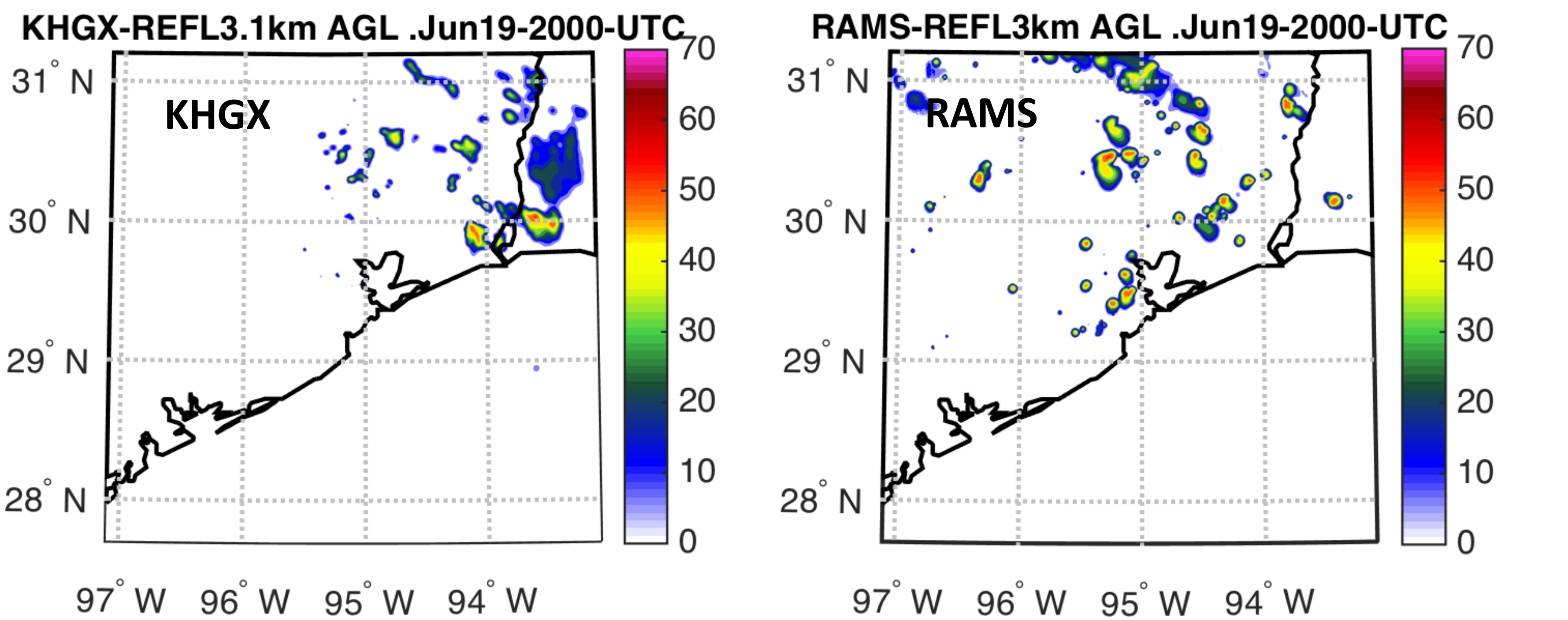
Scattered convective cells develop in north-western Texas

KHGX radar data provided by Marcus van Lier-Walqui and Ann Fridlind

Comparisons to Observations

June 19, 2013

- 3KM AGL Radar Reflectivity: 2000 UTC



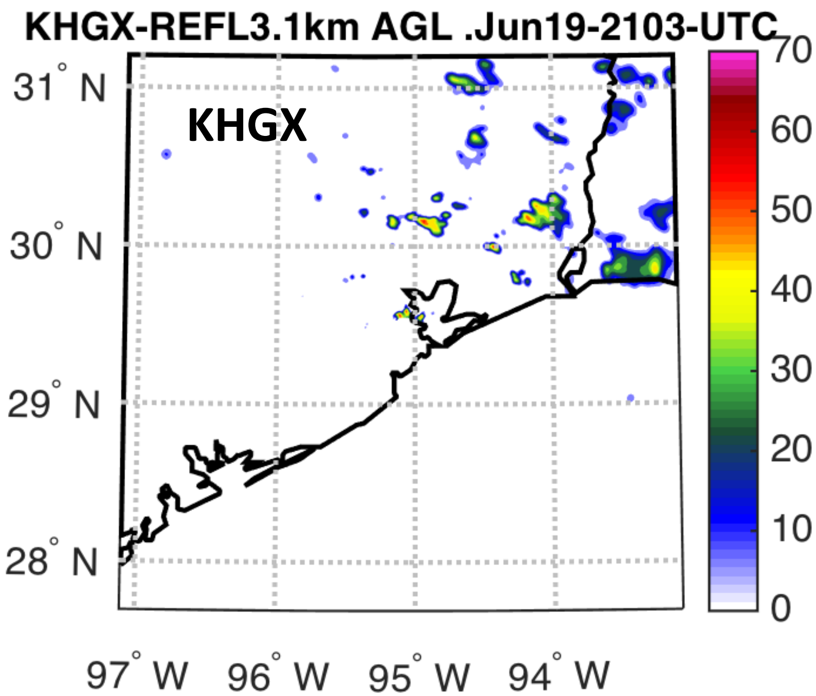
Scattered cellular development shifts southward near Houston area

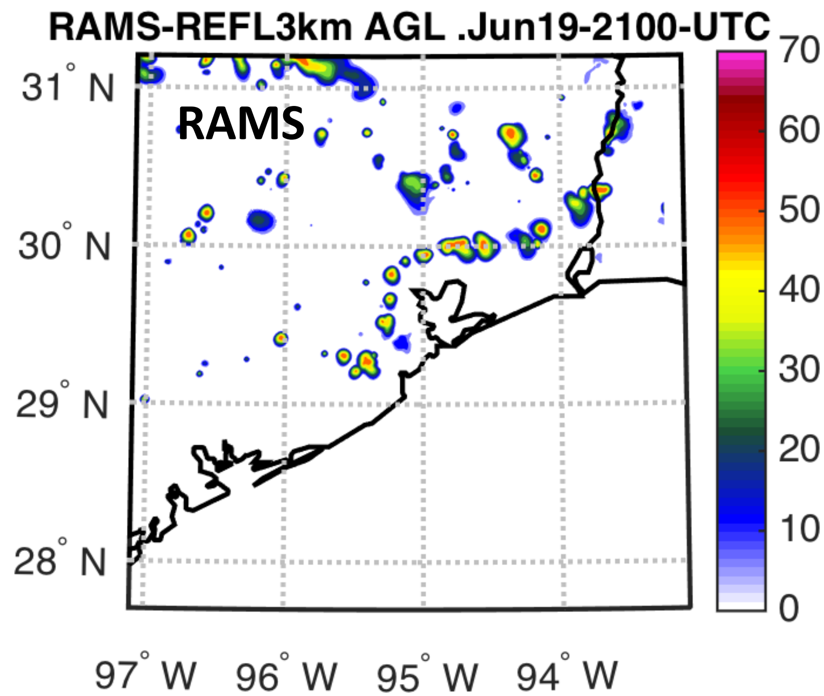
KHGX radar data provided by Marcus van Lier-Walqui and Ann Fridlind

Comparisons to Observations

June 19, 2013

- 3KM AGL Radar Reflectivity: 2100 UTC





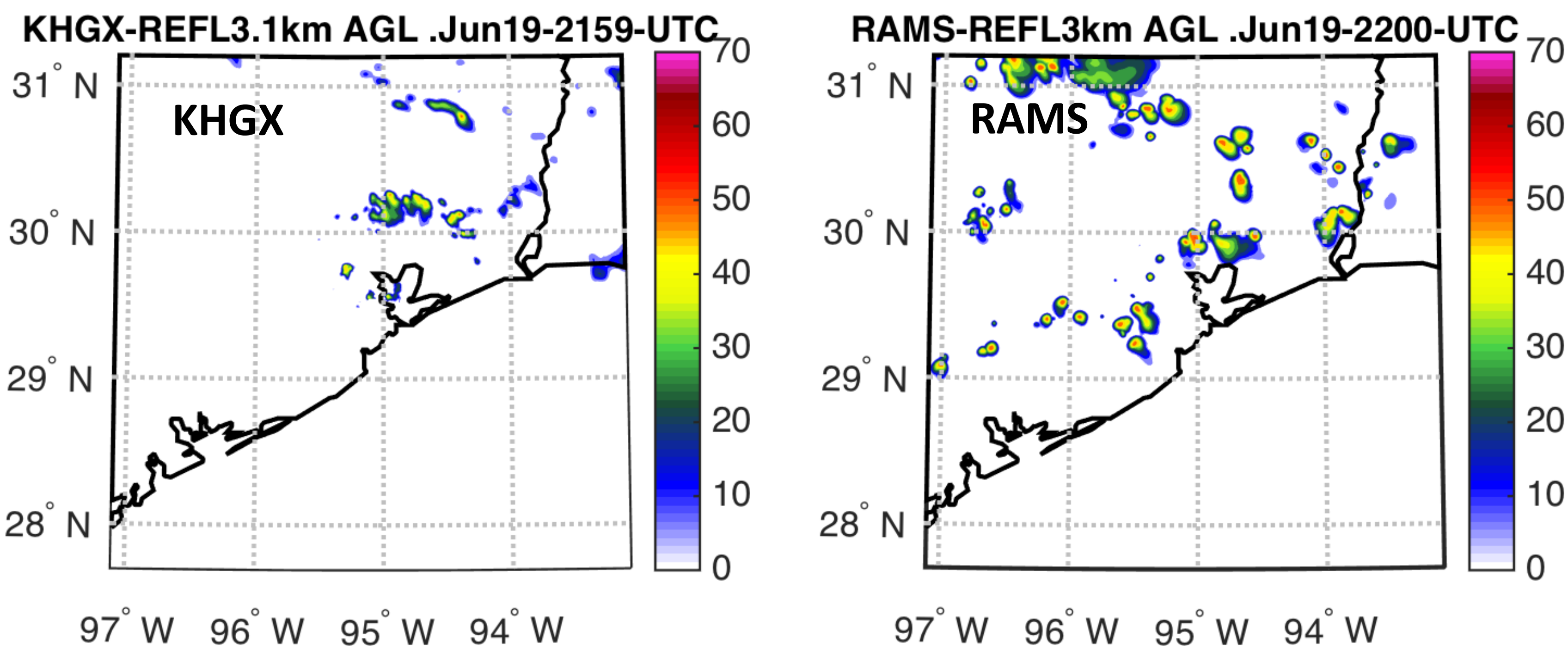
Scattered cellular development shifts southward near Houston area

KHGX radar data provided by Marcus van Lier-Walqui and Ann Fridlind

Comparisons to Observations

June 19, 2013

- 3KM AGL Radar Reflectivity: 2200 UTC



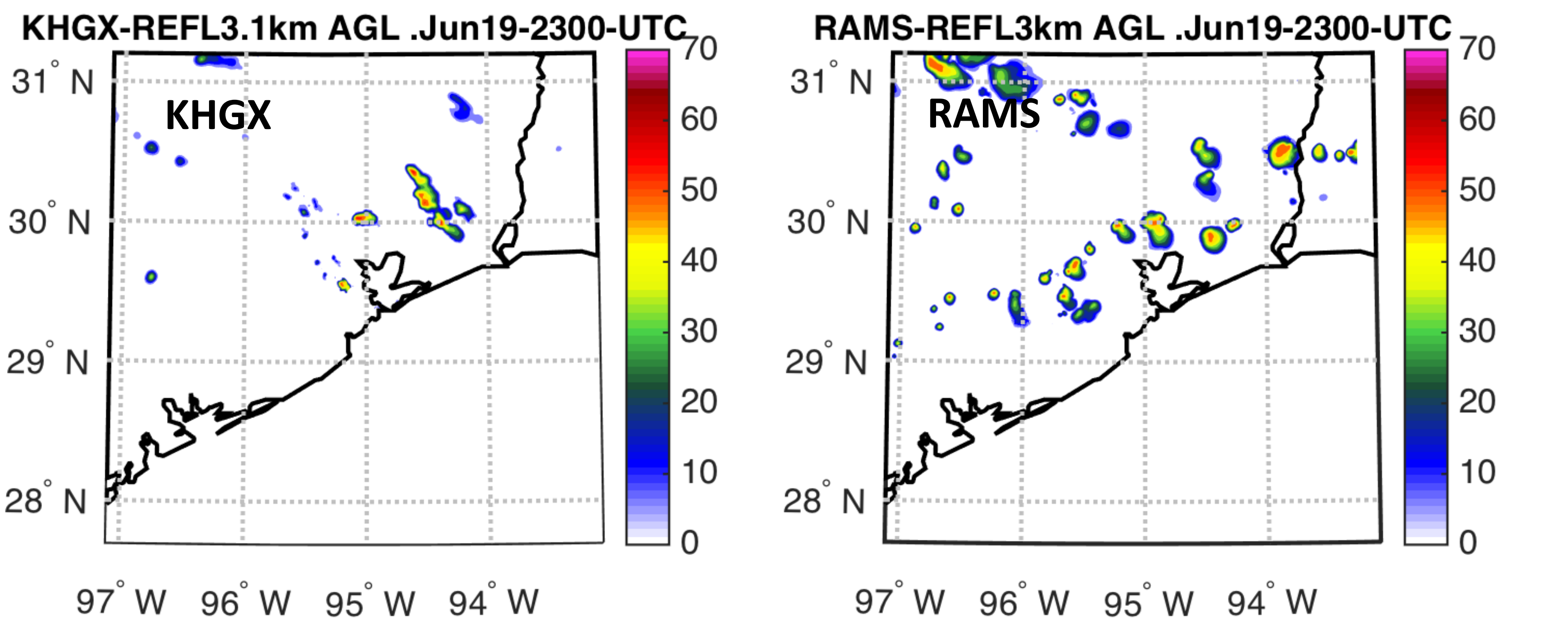
Scattered cellular development shifts southward near Houston area

KHGX radar data provided by Marcus van Lier-Walqui and Ann Fridlind

Comparisons to Observations

June 19, 2013

- 3KM AGL Radar Reflectivity: 2300 UTC



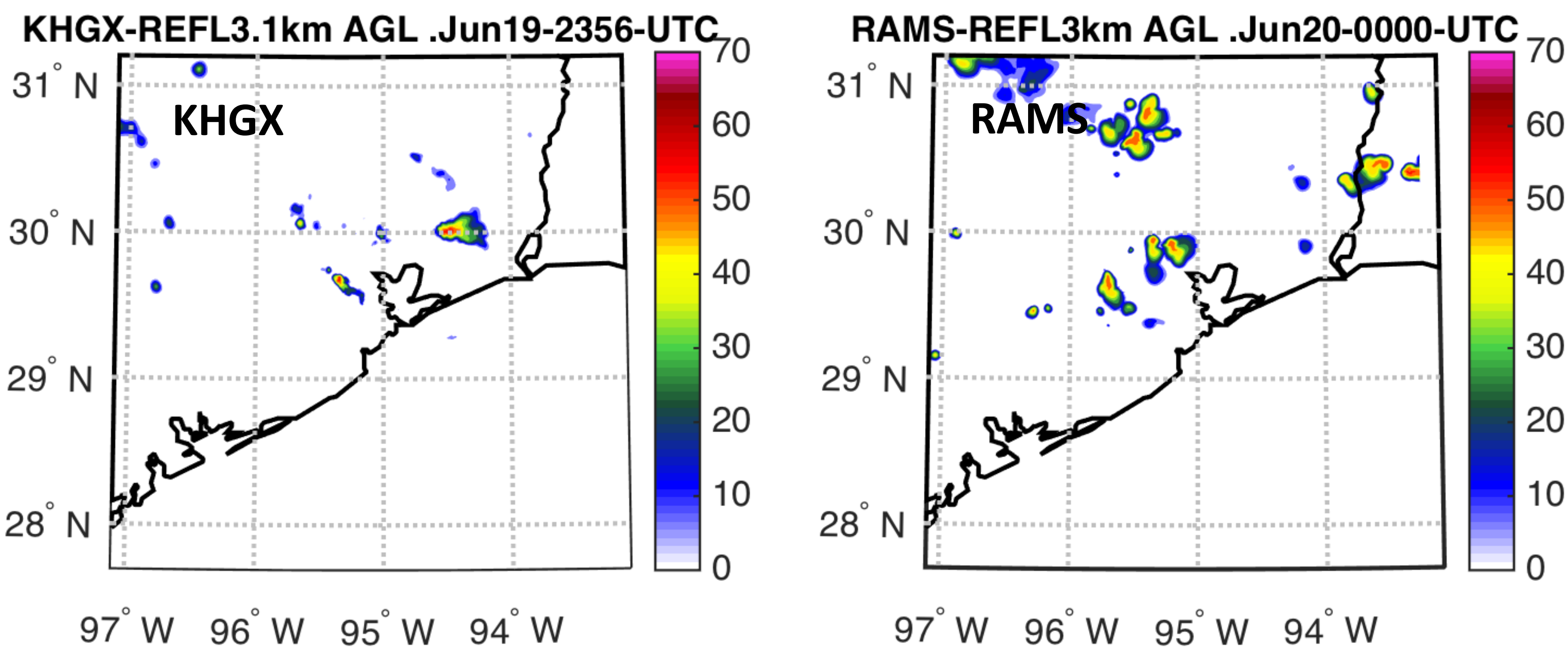
Scattered cellular development shifts southward near Houston area

KHGX radar data provided by Marcus van Lier-Walqui and Ann Fridlind

Comparisons to Observations

June 19, 2013

- 3KM AGL Radar Reflectivity: 2400 UTC



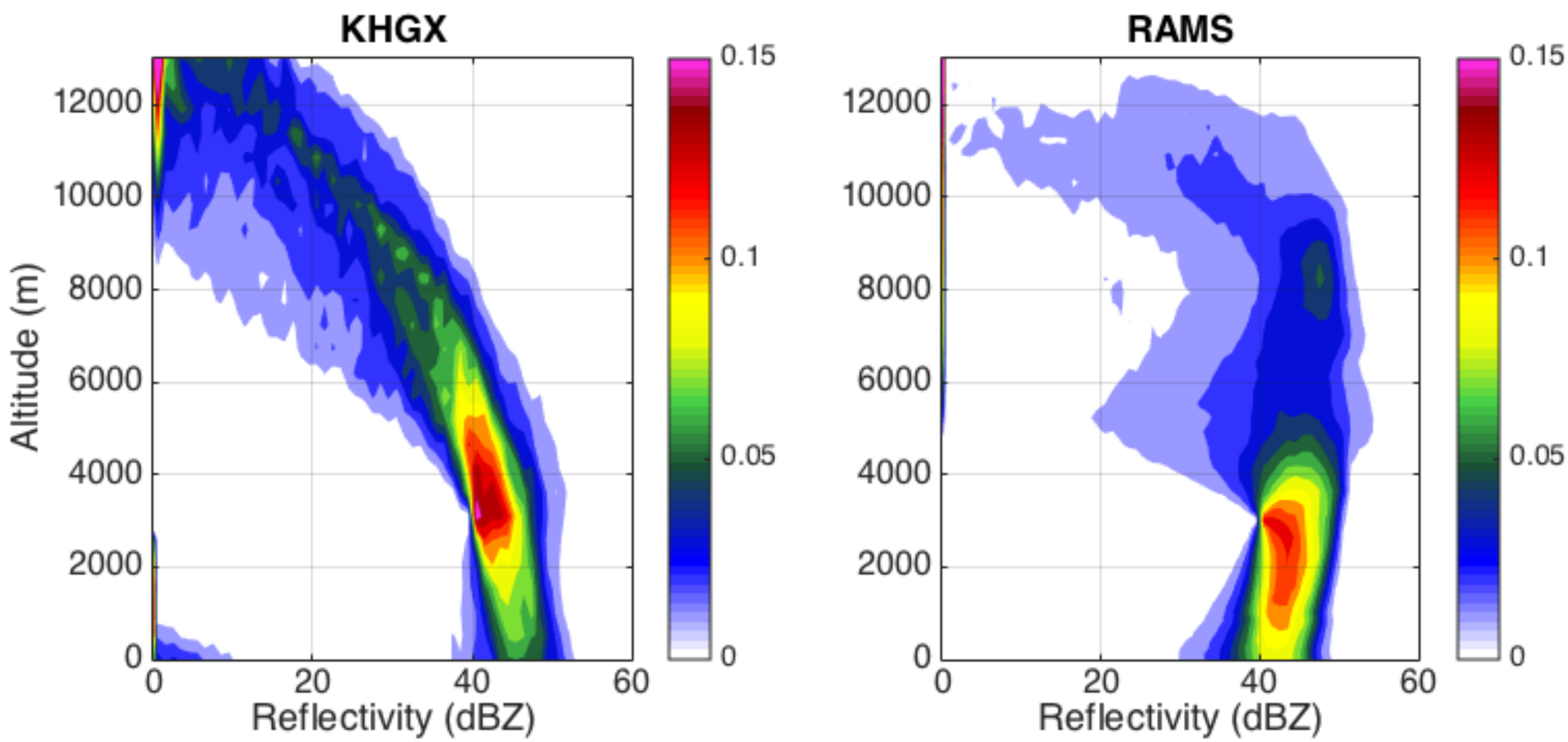
Convective cells become less widespread

KHGX radar data provided by Marcus van Lier-Walqui and Ann Fridlind

Comparisons to Observations

June 19, 2013

- Radar Reflectivity CFADs (06/19 1800UTC – 2400UTC)
  - Convective Grid Columns → 3KM AGL Reflectivity > 40 dBZ



KHGX radar data provided by Marcus van Lier-Walqui and Ann Fridlind

Approach

Part II: Observational Analysis

- Model evaluation - bring simulations as close as possible to the narrow list of well-observed quantities in order to facilitate evaluation
- Observations will be used both in conjunction with the case study simulations, and separately as another tool to study aerosol-cloud interactions => SQ2
- Details already covered

Approach

Part III: Box Closure Study

- CRM ensemble provide high spatial and temporal resolution data to address feasibility of conducting a box closure study for a GCM grid box, as outlined in Rosenfeld et al. (2014).
- Simulation data will be used to calculate precise energy, moisture, momentum and aerosol fluxes across a region representing a GCM grid box (~100 x 100km in horizontal extent and to the top of the tropopause in vertical extent).

Approach

Part III: Box Closure Study

- Hypothetical field campaign sampling techniques will be applied to model data to determine temporal frequency and spatial resolution of observations necessary to calculate synthetic flux measurements => SQ3
- The large-scale GCM box flux measurements will be calculated for all CRM simulations in order to quantify variability in energy, moisture, momentum and aerosol fluxes to aerosol perturbations across the different CRMs => SQ1

Next Steps

- Encourage modeling groups to participate in the study
- Only 2 simulations are needed and the basic setups are described in the roadmap => limited model tinkering
- Initial results at ACPC meeting (April 2017)
- Finalize simulation performance and analysis by end of 2017
- Several DCC manuscripts planned including a description of field campaign needs