- ❑ Which water-related limitation(s) in process-understanding, modeling, and monitoring in the Western U.S. and Canada require a large, 5-10 year integrated and interdisciplinary team approach?

Water Availability

How much, Where, When, Access, "If"?

fluxes, storage and redistribution, timing

white water,

blue water, greenwater,

brownwater

pipewater

Multiscale, Multiphysics, Multimedia

(models and observations)

Organization

Cross-Scale Consistency and Transfers (nm-continental scale)

Technology

Remote Sensing

Science-Grade Multiscale Integrated Sensors

Modeling – Parameterizations, Numerics, Hardware, DATA

Ana P. Barros

iphex.pratt.duke.edu

8 years, hourly, 1 km resolution
50 hourly ensmbles at 1 km resolution…. Could generate more
Also at 250 m resolution

Outline

- Mutiscale Observations – Processes/Rates/Thresholds
- Imperfect Models
- Multiscale Physics
- Process Controls at Small/Short Scales
- Emergent Dynamical Organization at Large/Long Scales

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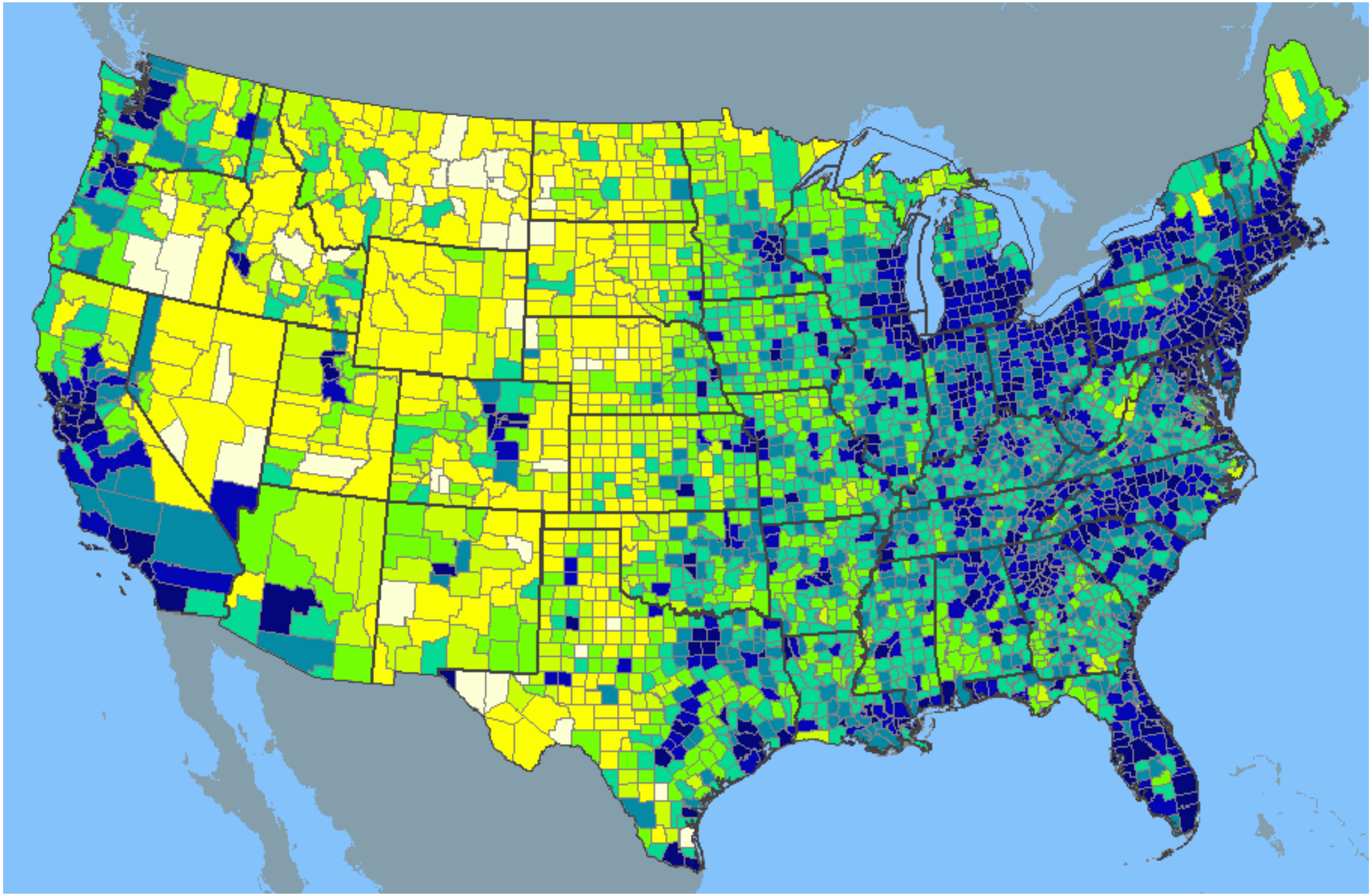
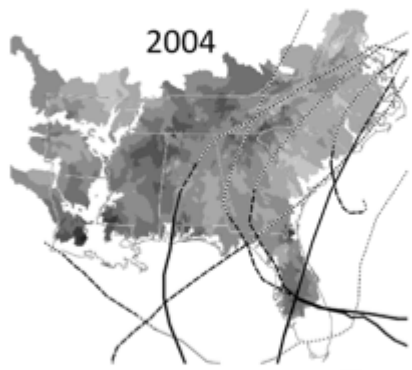
US Population Density



Mapping and Understanding Nonlinearity and Multiscale Memory

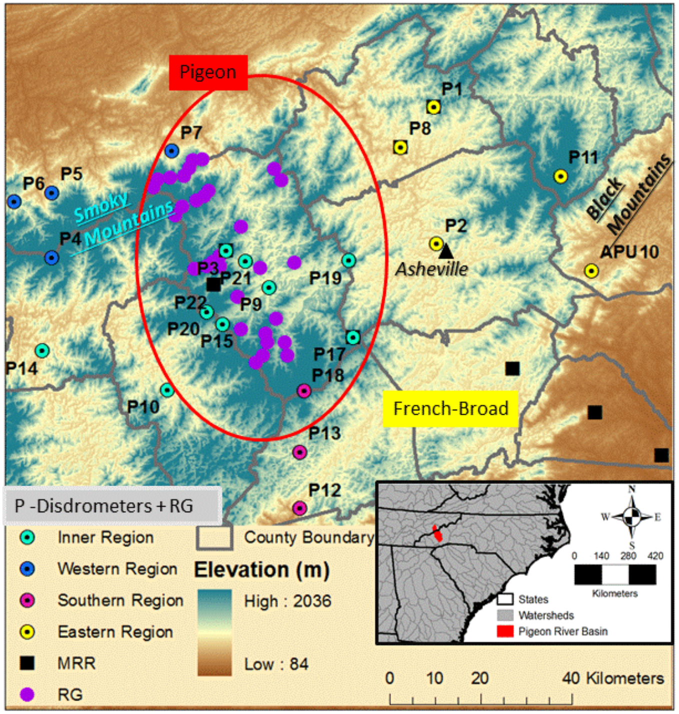


Brun and Barros, IJOC 2014
Lowman and Barros, 2016, JRG -Biogeosciences

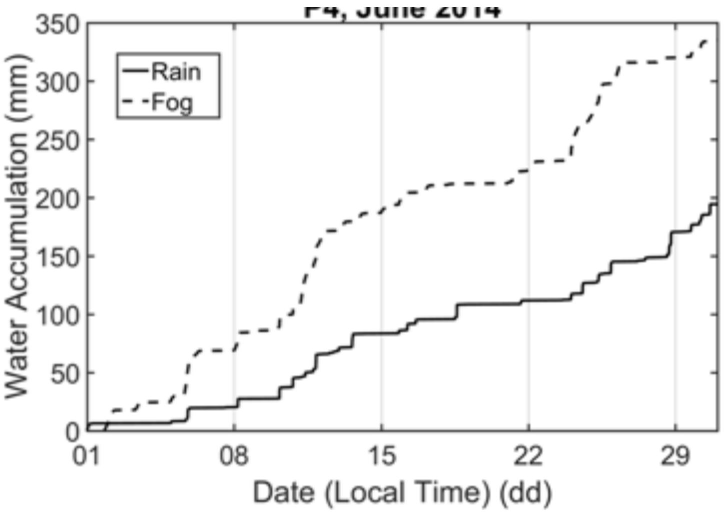
Low Level Cloud Immersion

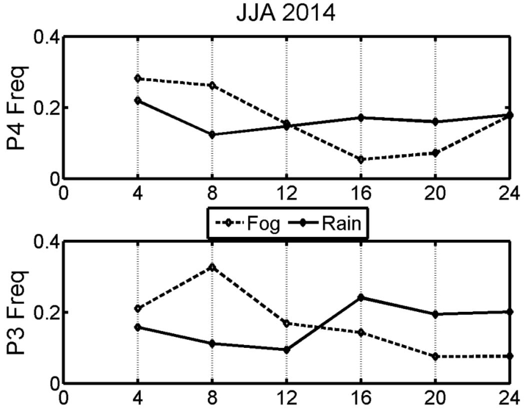
30/10/2009 7:24 AM

Southern Appalachian Mountains



Clingman's Dome, P4, June 2014





Time (End Hours, LT)

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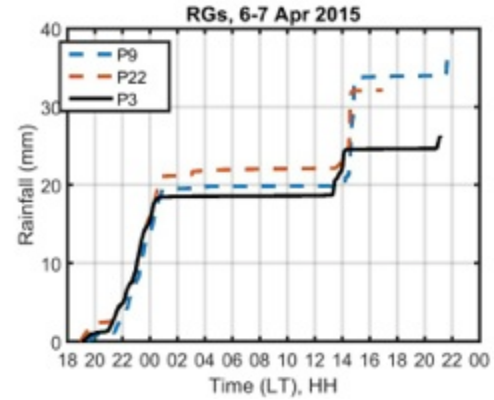
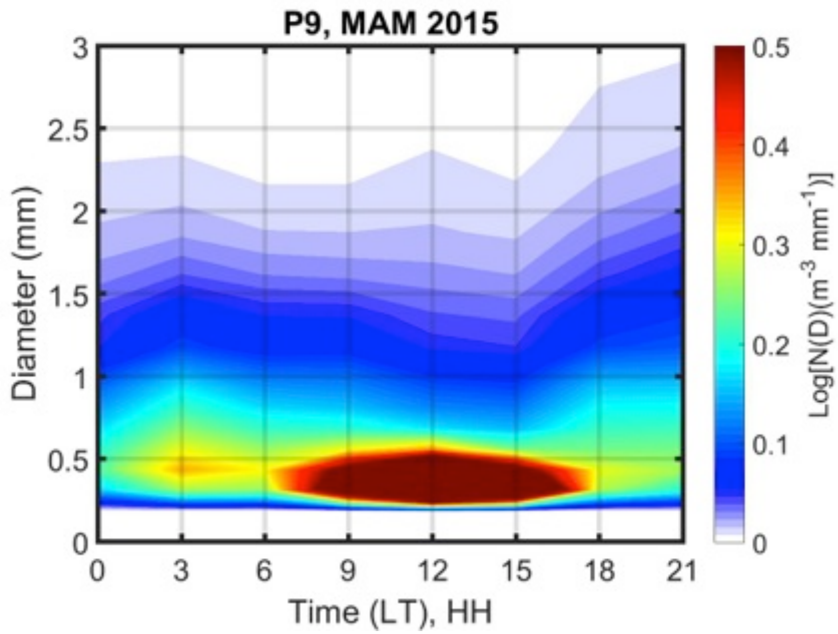
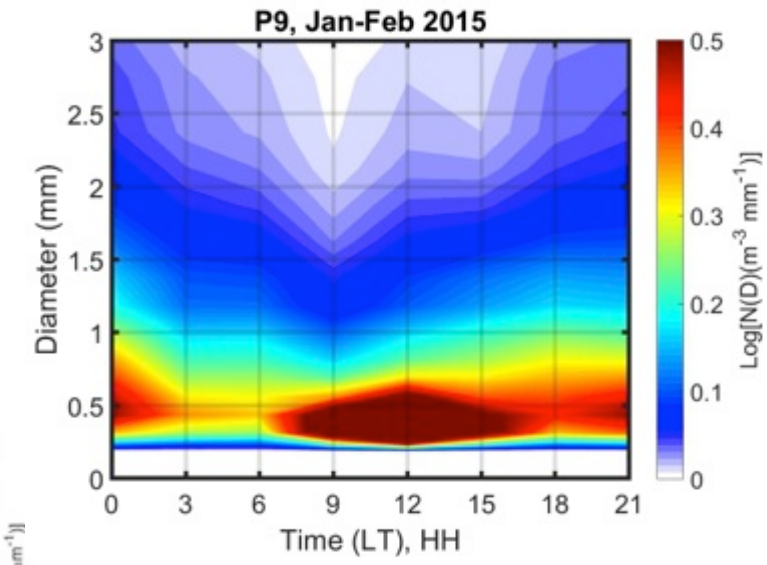
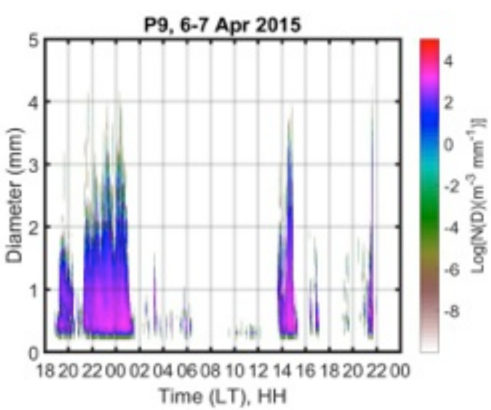
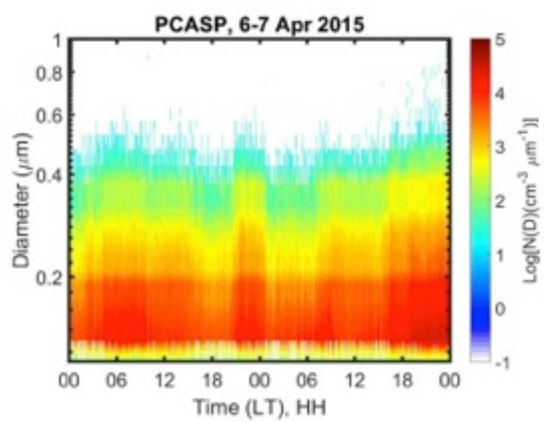
Reverse Orographic Enhancement











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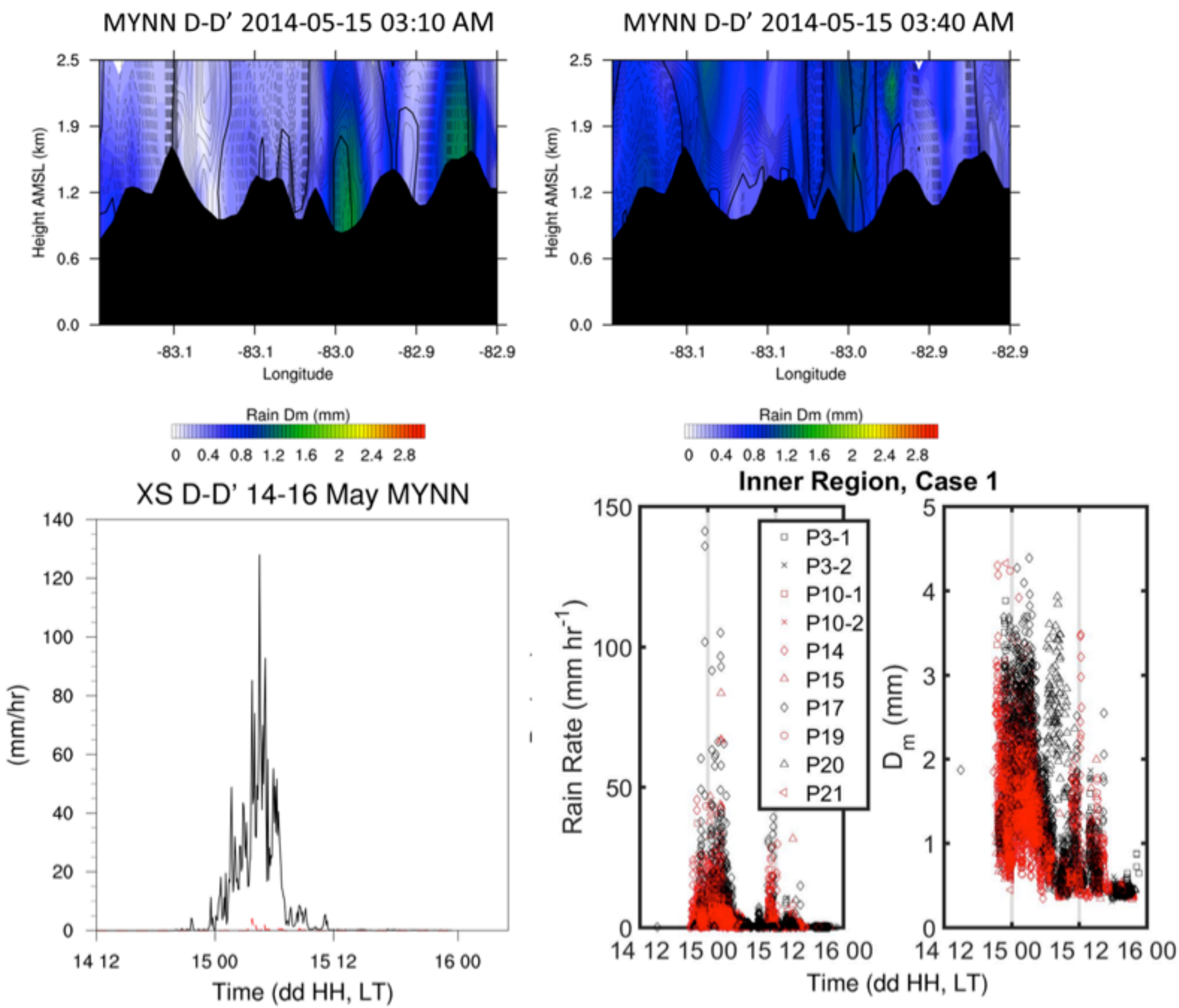
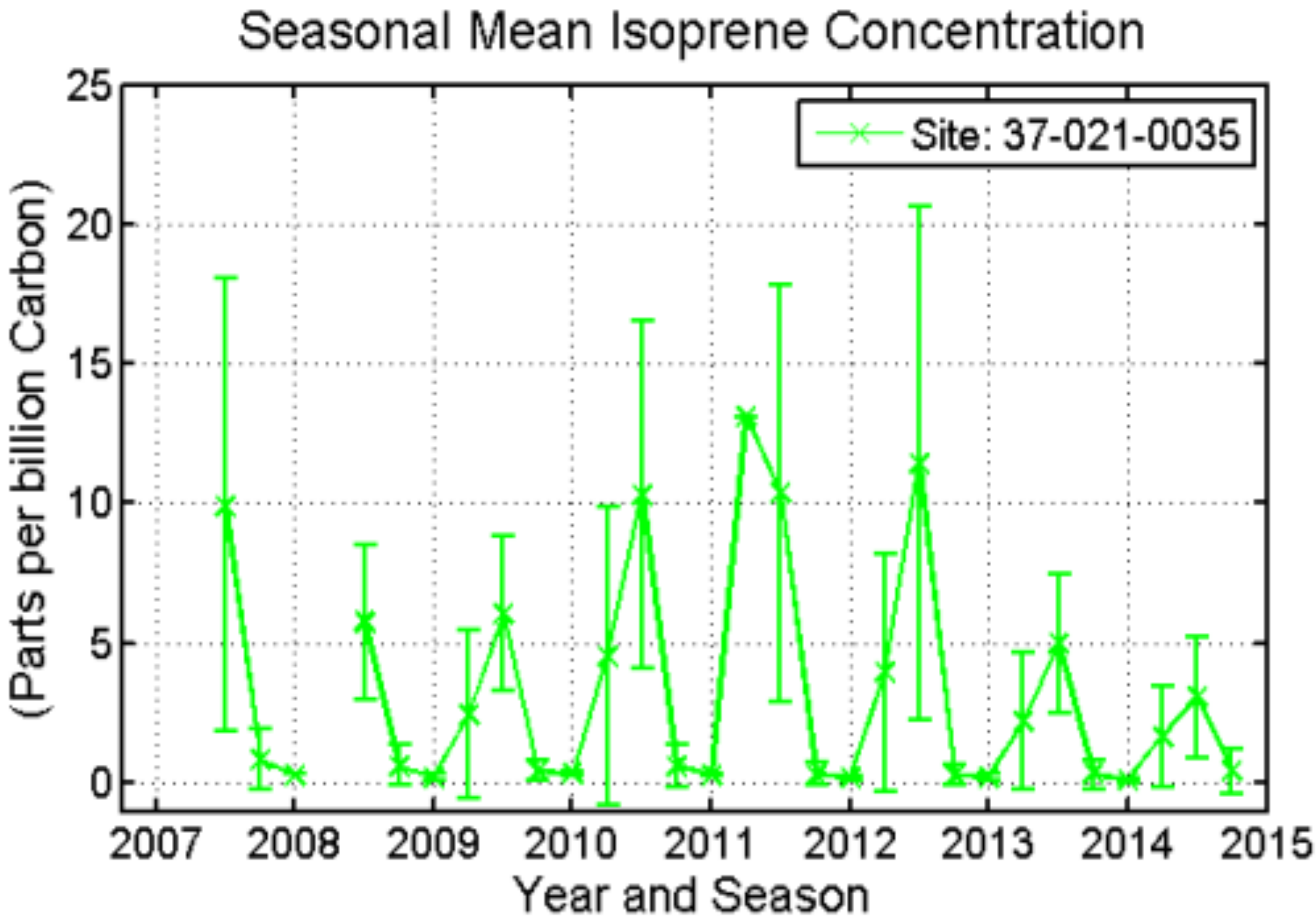
Wilson and Barros, JAS 2014, JH 2015

Seeder-Feeder Interactions



Wilson and Barros, 2016



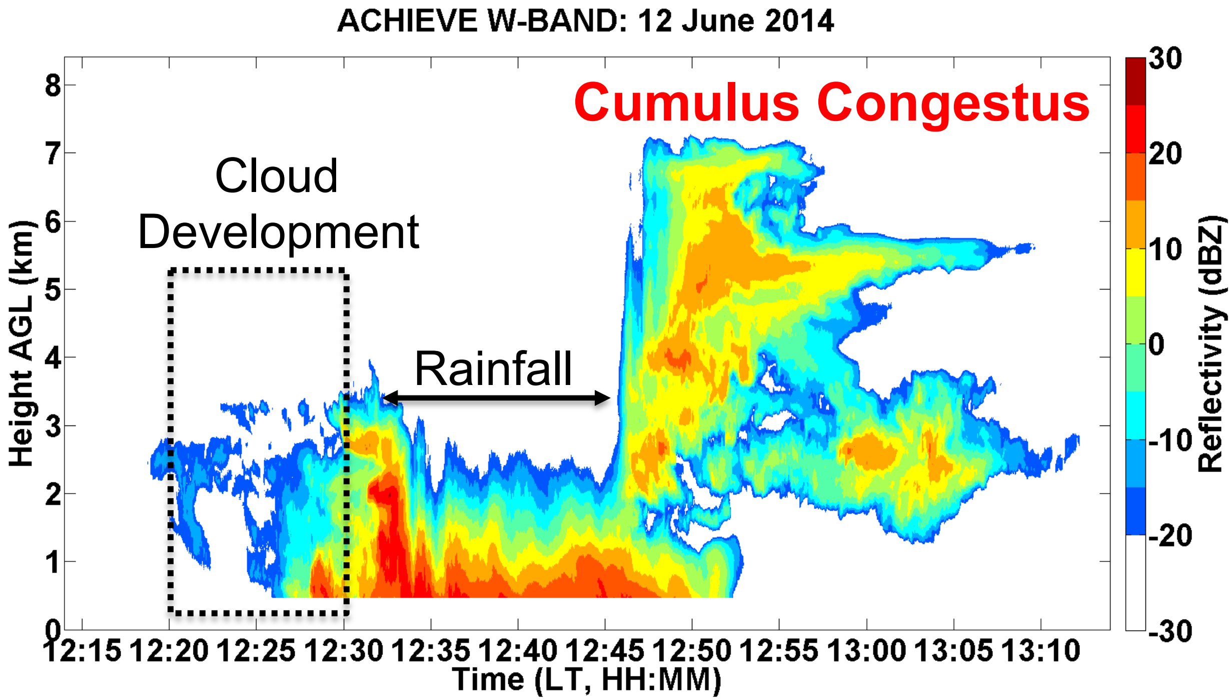
Wilson and Barros, 2016

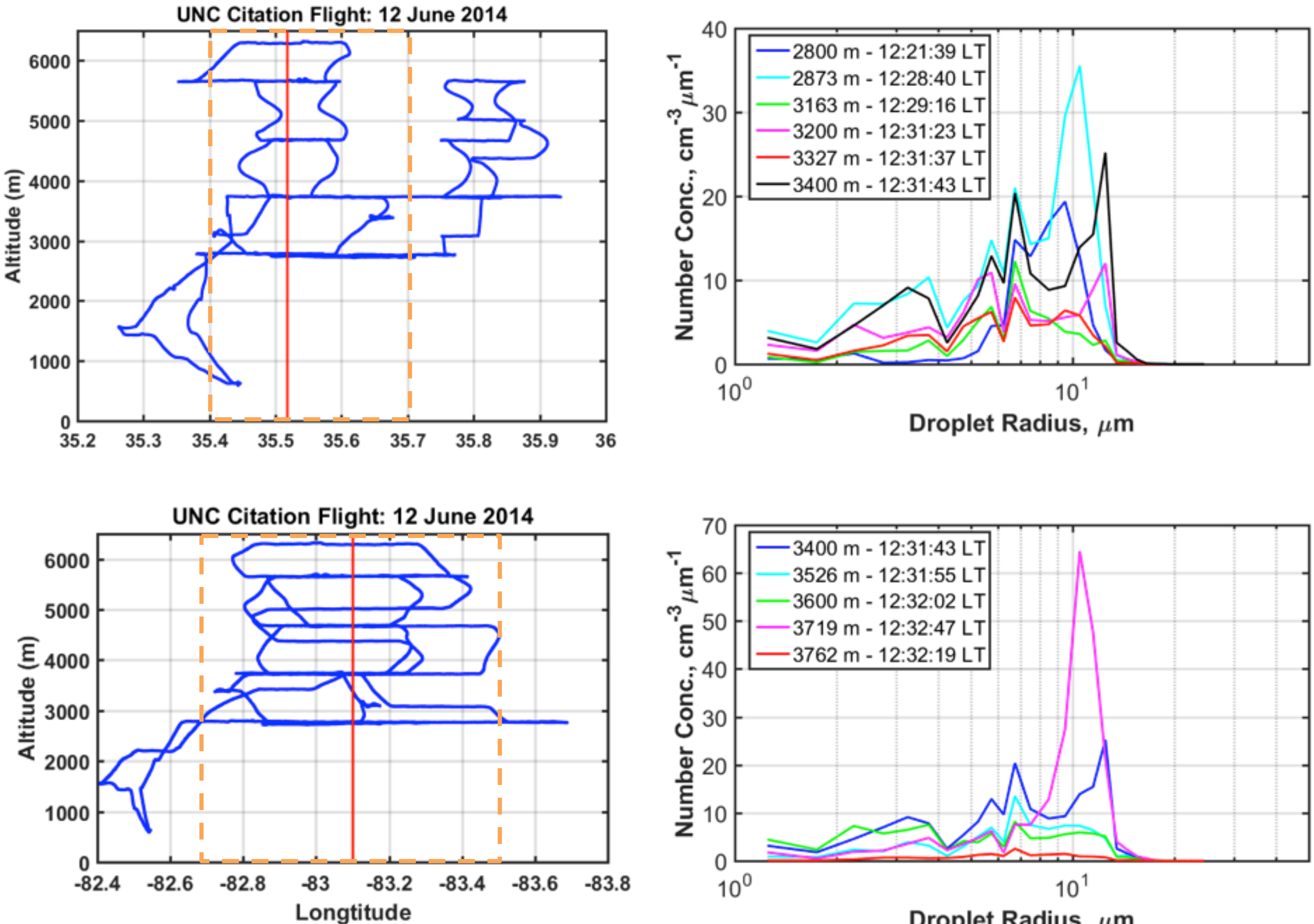
Case Study during IPHEx

- *Atmospheric Thermodynamic State:* *WRF* sounding
  (horizontal res. = 250 m; vertical res. = 30 m)
- Cloud base height (CBH): WRF sounding and ceilometer
- *Aerosol Properties:* Aerosol number distribution, hygroscopic parameters (κ) at the surface

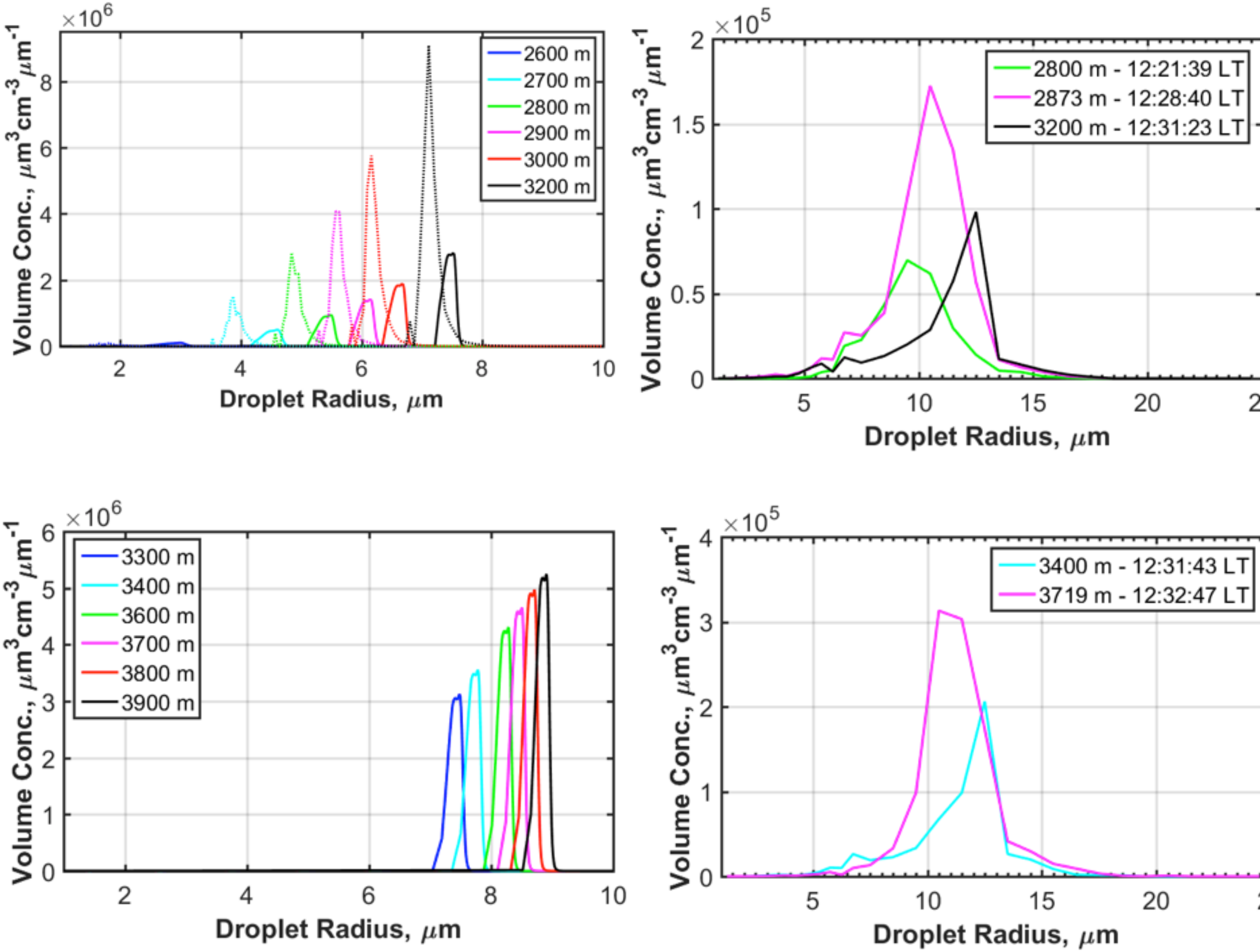
Model Run Setup:

- V_0 = 2.0 m/s
- CBH = 2550 m
- R = 1000 m
- T_0 = 0.5 K > T_{env}
- 200 bins, geometric grid



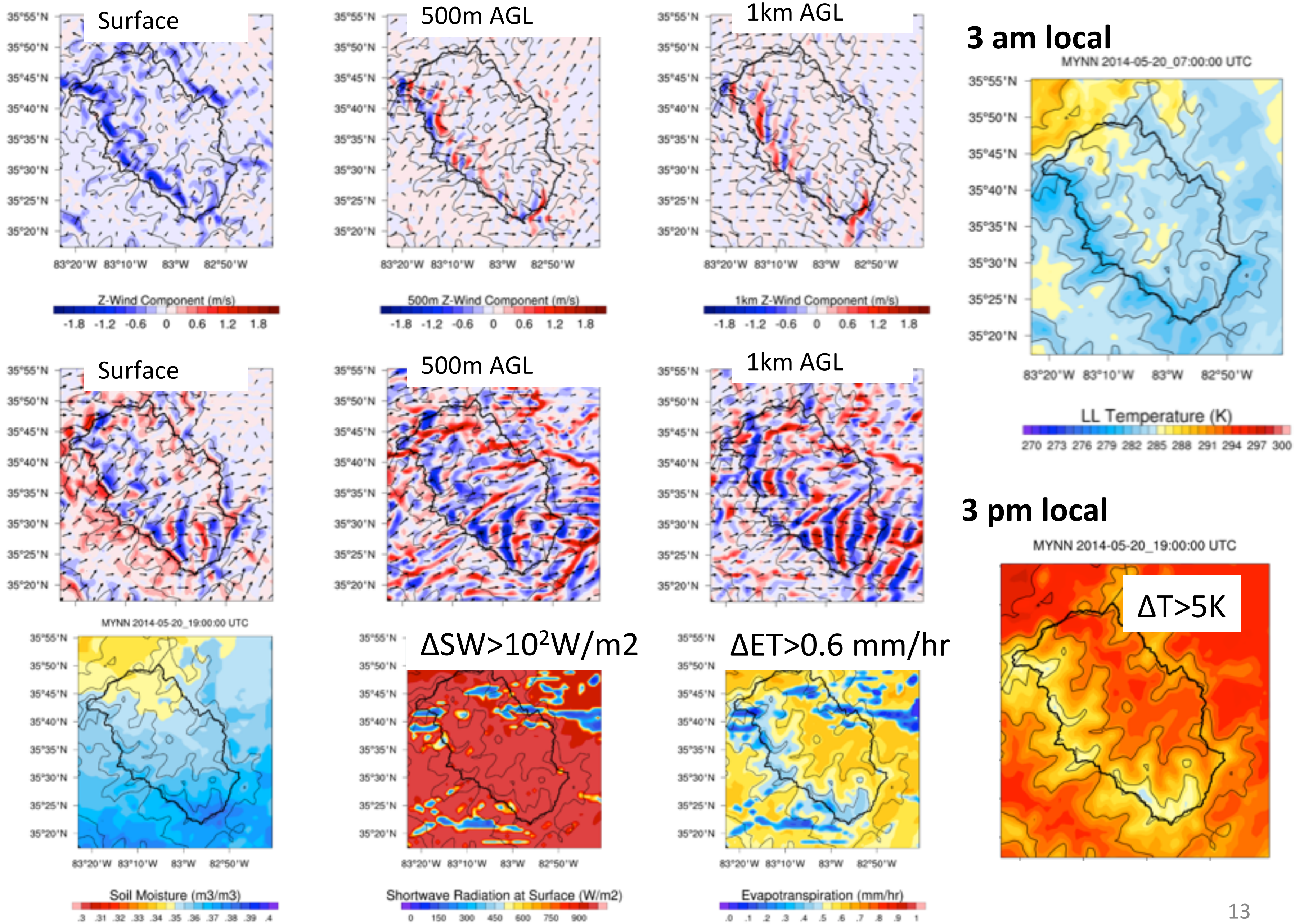


UNC Citation Flight: 12 June 2014
Altitude (m)
0
1000
2000
3000
4000
5000
6000
35.2
35.3
35.4
35.5
35.6
35.7
35.8
35.9
36
Number Conc., cm^{-3} μm^{-1}
0
10
20
30
40
2800 m - 12:21:39 LT
2873 m - 12:28:40 LT
3163 m - 12:29:16 LT
3200 m - 12:31:23 LT
3327 m - 12:31:37 LT
3400 m - 12:31:43 LT
10^0
10^1
Droplet Radius, μm
UNC Citation Flight: 12 June 2014
Altitude (m)
0
1000
2000
3000
4000
5000
6000
-82.4
-82.6
-82.8
-83
-83.2
-83.4
-83.6
-83.8
Longtitude
Number Conc., cm^{-3} μm^{-1}
0
10
20
30
40
50
60
70
3400 m - 12:31:43 LT
3526 m - 12:31:55 LT
3600 m - 12:32:02 LT
3719 m - 12:32:47 LT
3762 m - 12:32:19 LT
10^0
10^1
Droplet Radius, μm

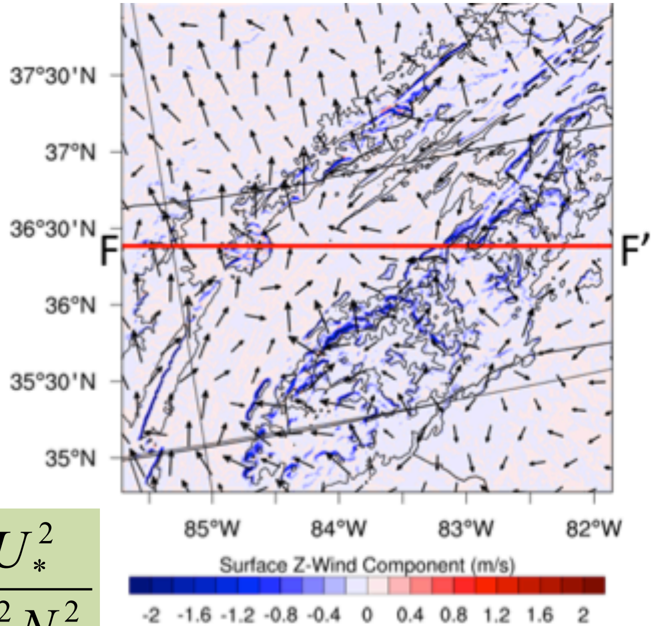


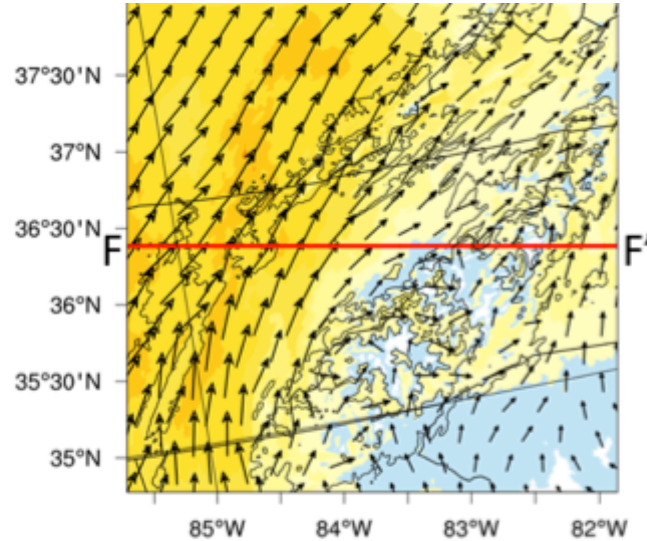
×10^6
Volume Conc., μm^3cm^-3μm^-1
Droplet Radius, μm
2600 m
2700 m
2800 m
2900 m
3000 m
3200 m
×10^5
Volume Conc., μm^3cm^-3μm^-1
Droplet Radius, μm
2800 m - 12:21:39 LT
2873 m - 12:28:40 LT
3200 m - 12:31:23 LT
×10^6
Volume Conc., μm^3cm^-3μm^-1
Droplet Radius, μm
3300 m
3400 m
3600 m
3700 m
3800 m
3900 m
×10^5
Volume Conc., μm^3cm^-3μm^-1
Droplet Radius, μm
3400 m - 12:31:43 LT
3719 m - 12:32:47 LT

DIURNAL CYCLE OF FLOW – 20 May

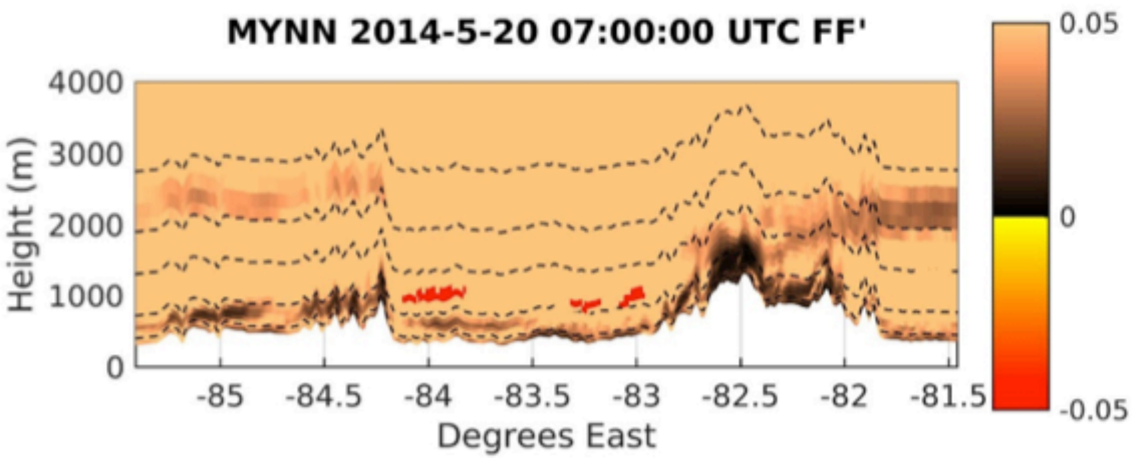


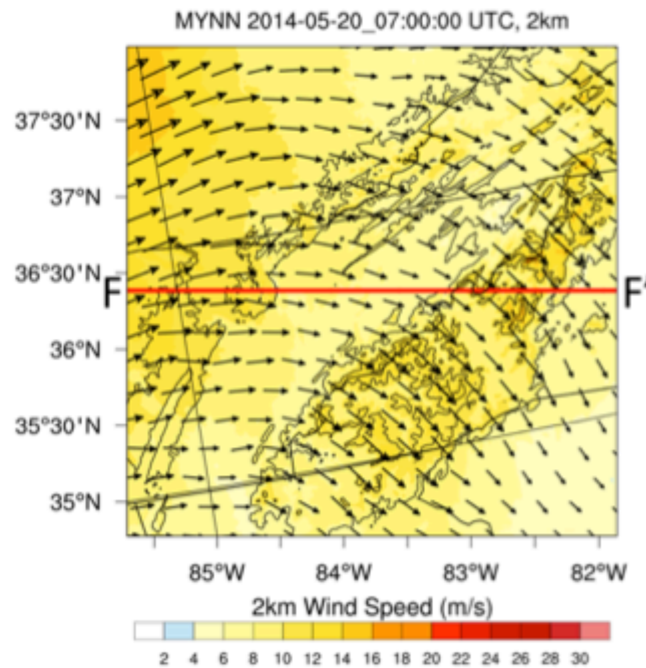
DECOUPLING EVIDENCE– 20 May, 3 am



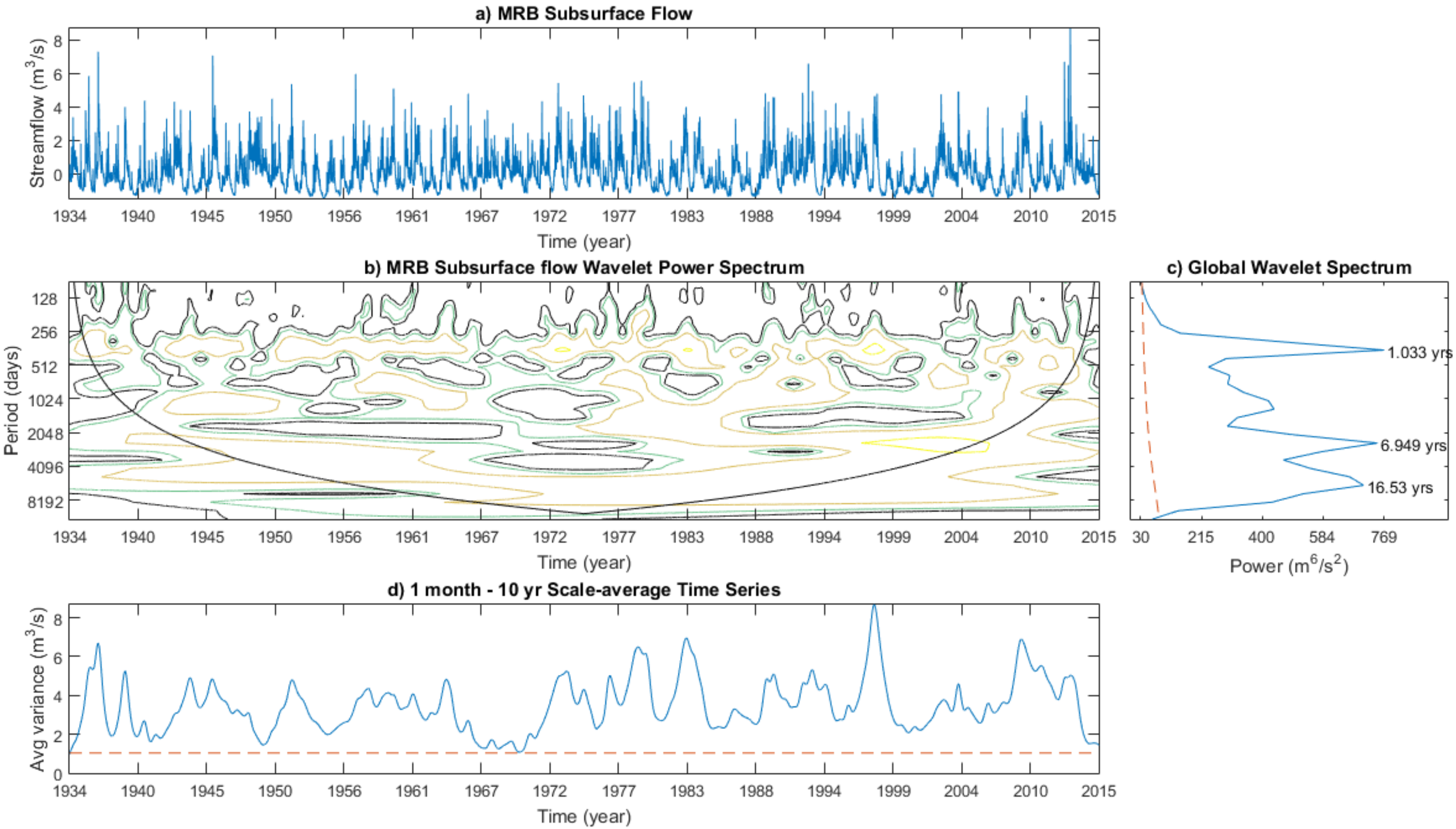


$$Fr^2 = \frac{U_*^2}{h^2 N_m^2}$$





2. Coupled Human and Natural Systems



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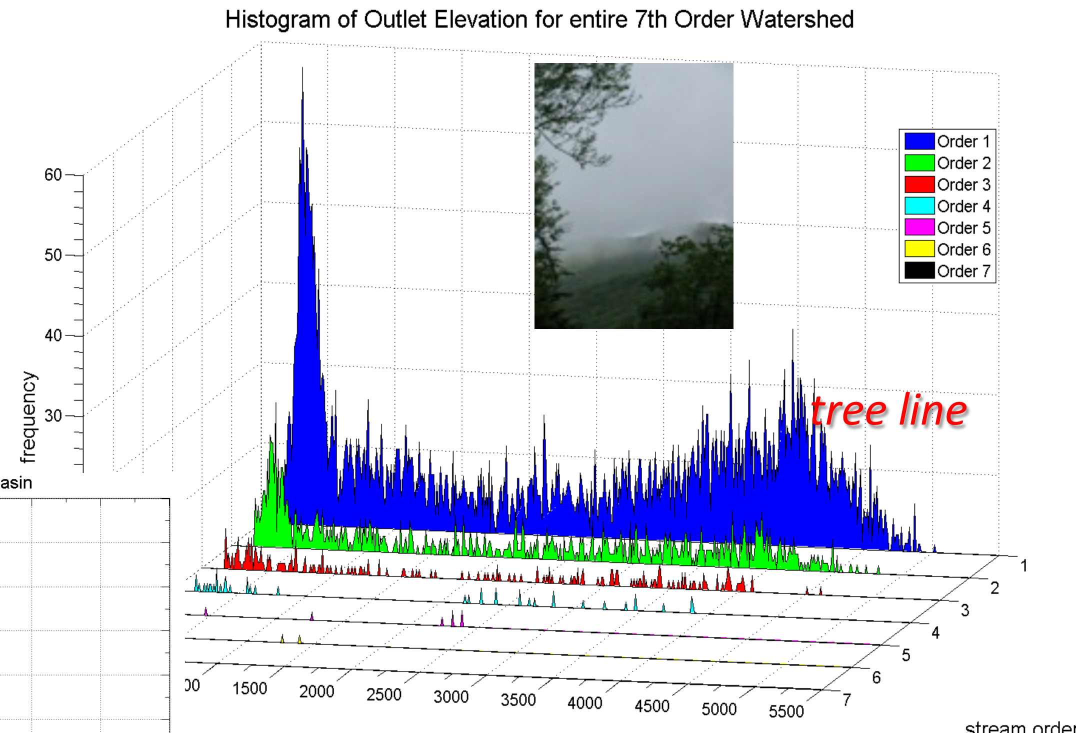
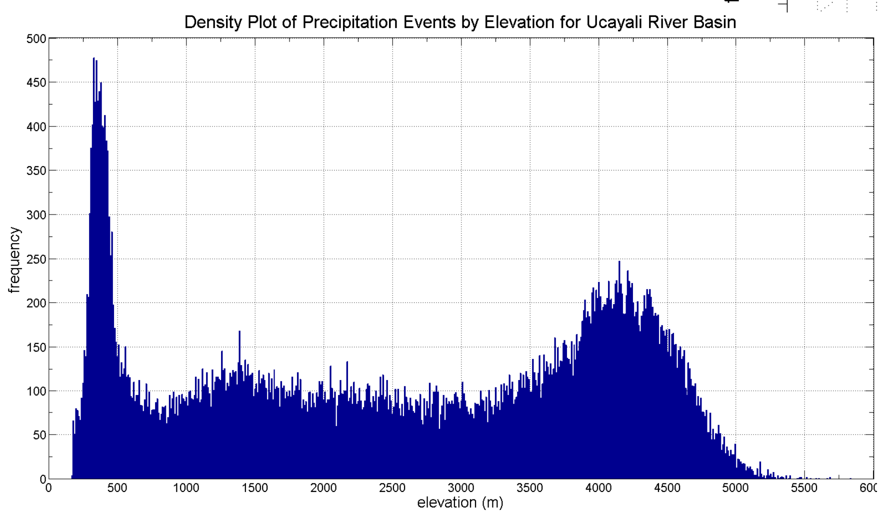
Hodes and Barros, 2016

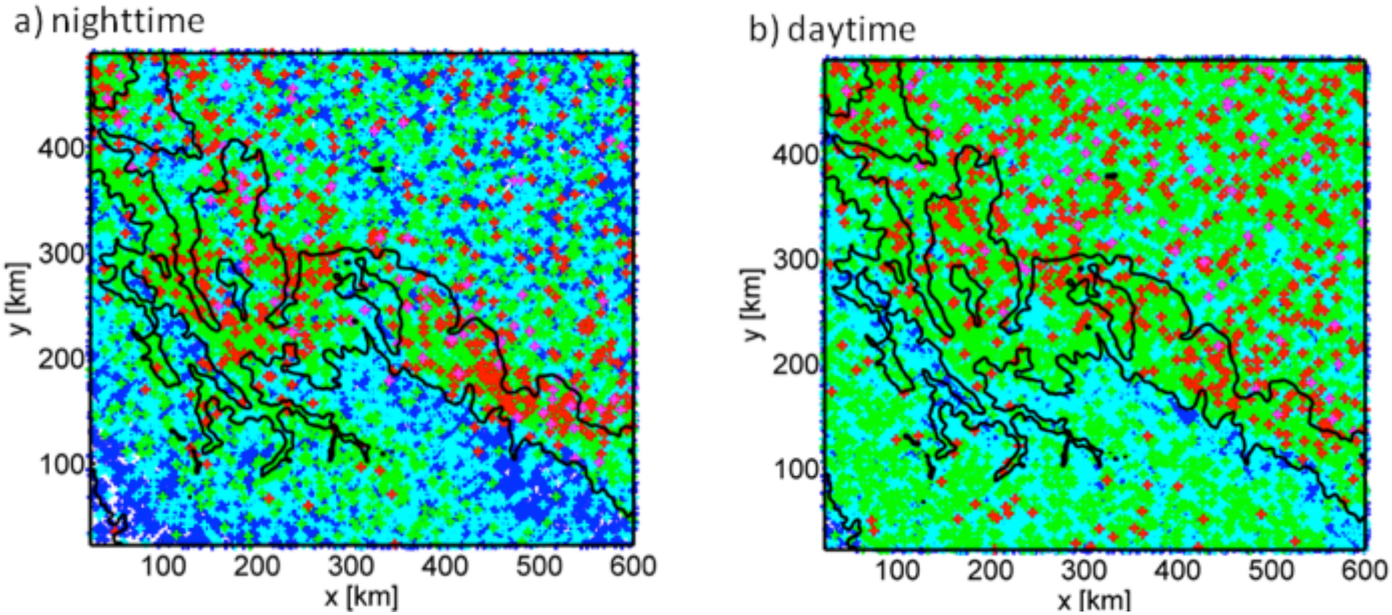
Multiscale Precipitation Processes Over Mountain Terrain – Landform and Vegetation Controls of Microphysics and Convection i





Lowman and Barros, 2014 JGR

TRMM Rainfall (13 years)

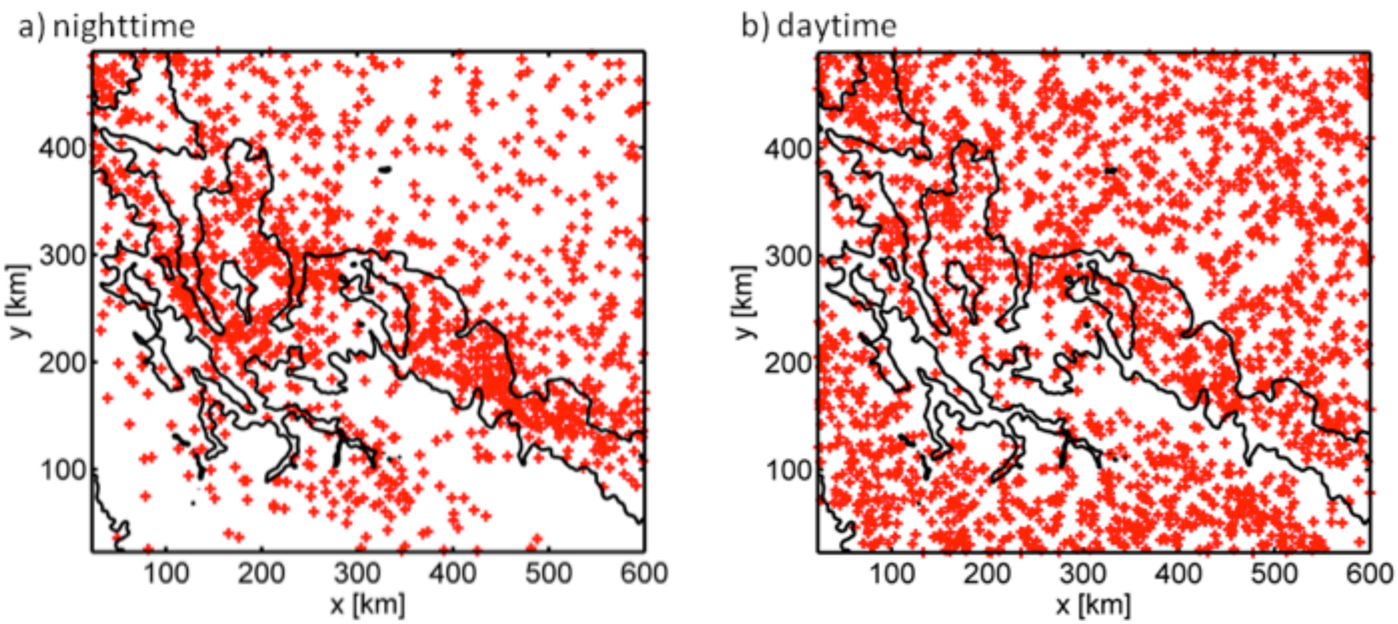


Precipitation

cm/yr

50-300% error

m/yr



Spatial Composite of Convective Features

Liu et al. 2008

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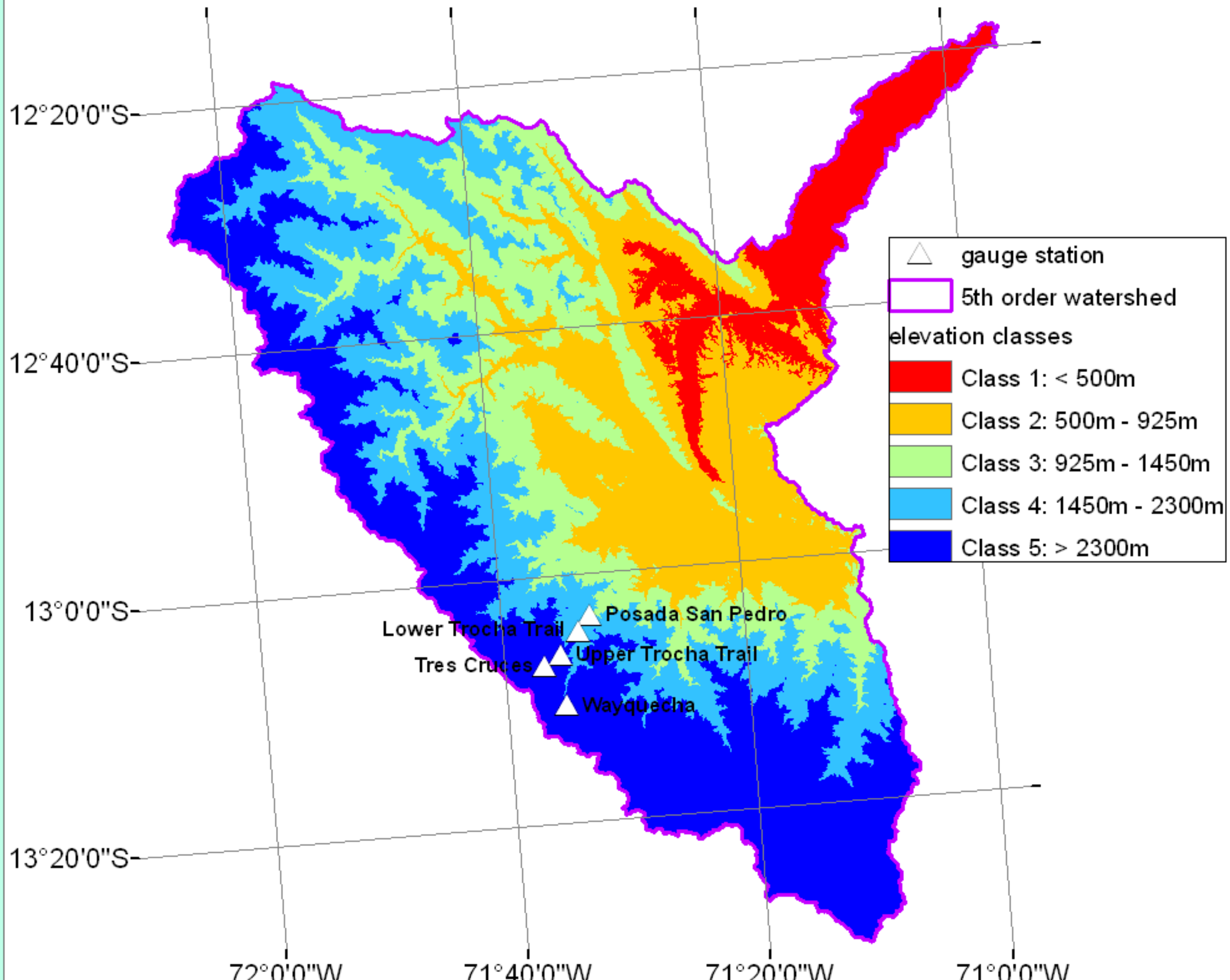
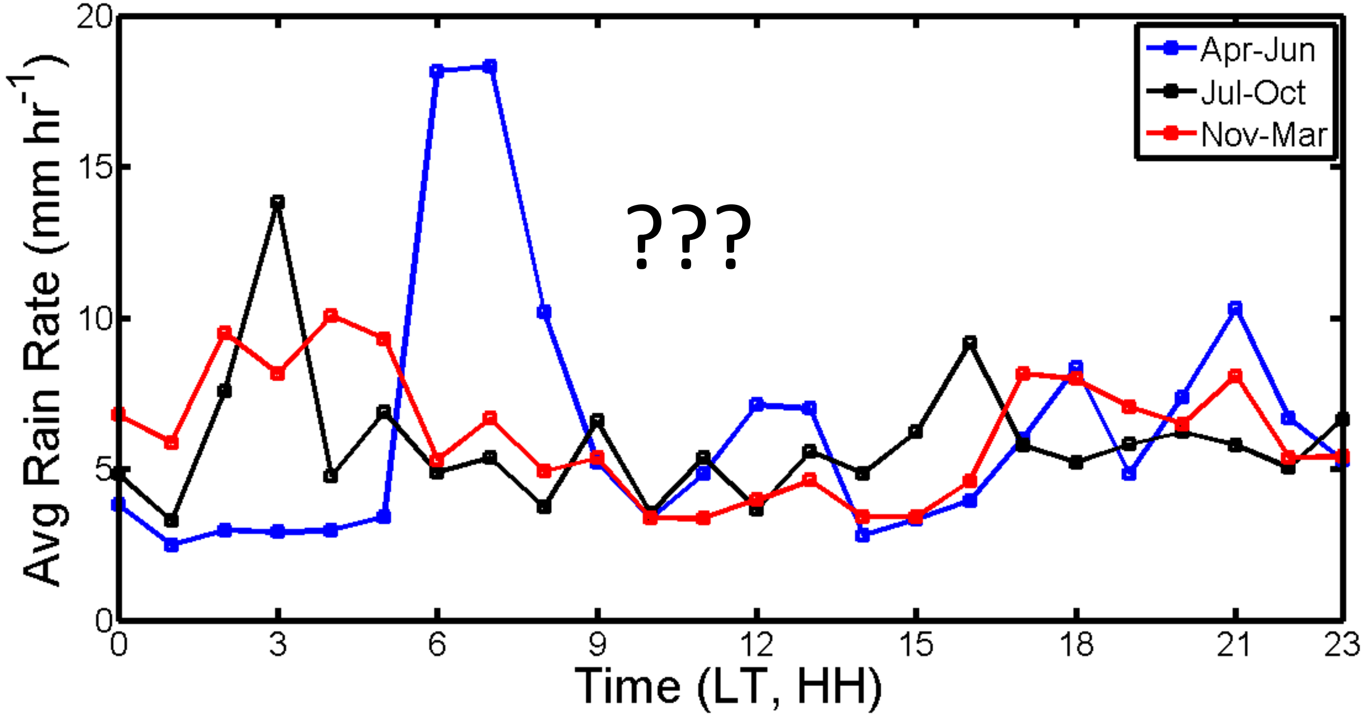
Locations of Rain Gauge Stations in Madre de Dios River Basin in Andes Mountains



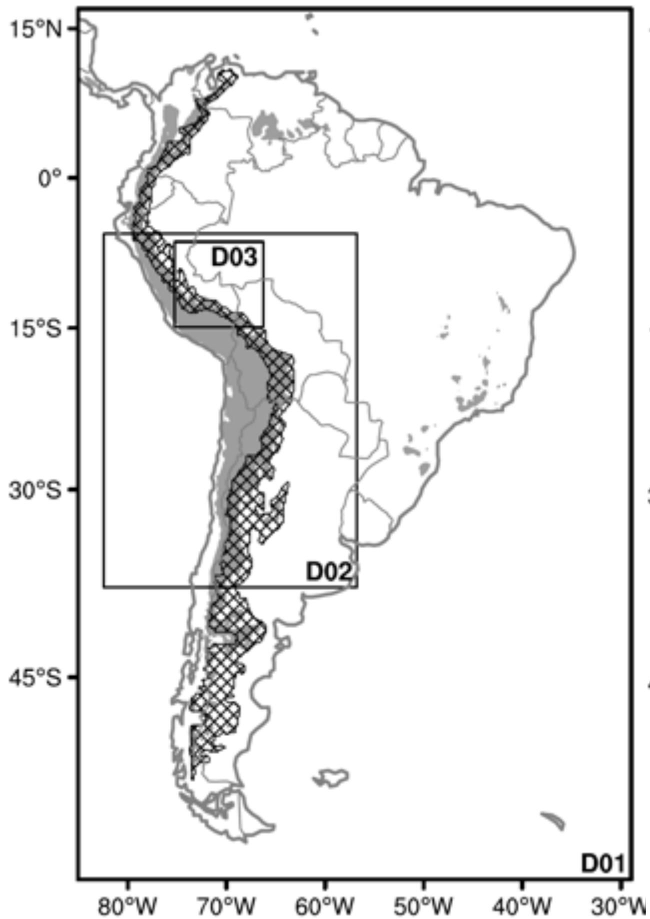
Cloud Forest



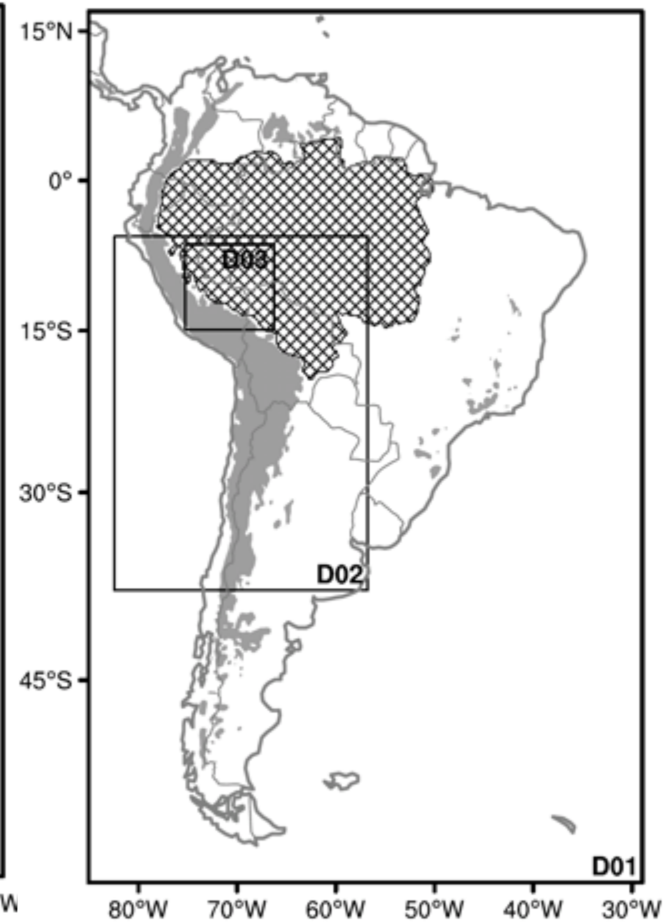
Land-Atmosphere Interactions

ET Suppression Experiments Using WRF

EADS

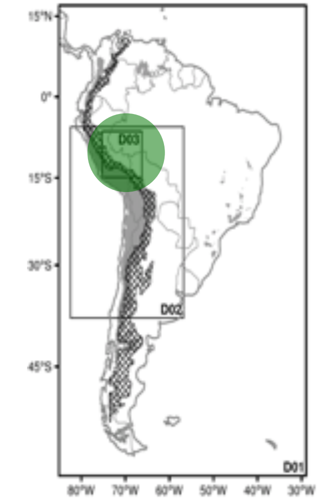


AMZL

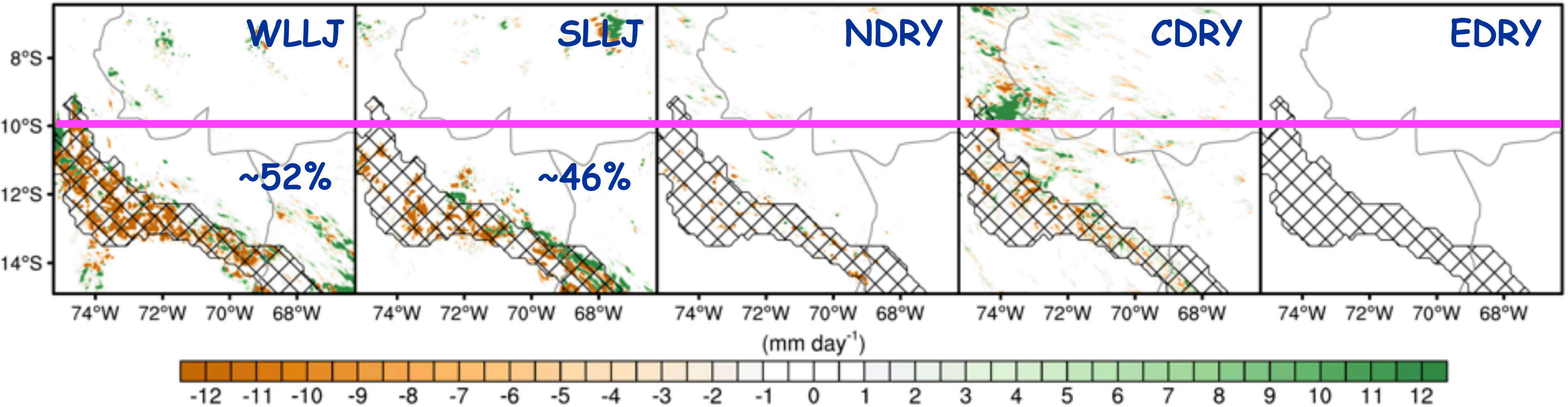


Atmospheric profiles — **CTL** — **STRICT**

Sun an Barros, 2014 JAS
Sun and Barros, 2015 QJRMS



Daily Precipitation (D03; STRICT-CTL)



Sun and Barros, JAS 2015

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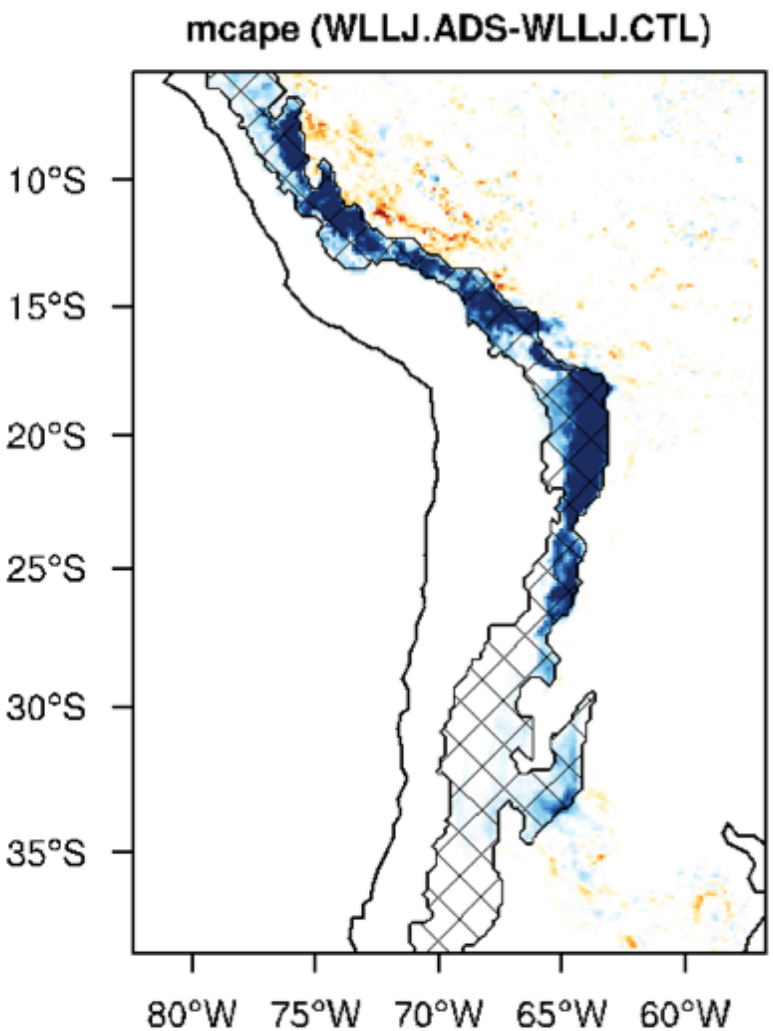
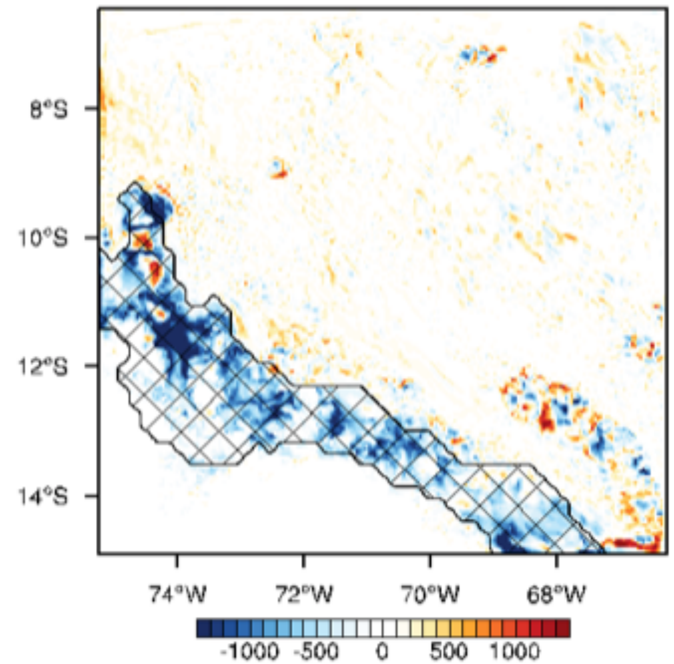
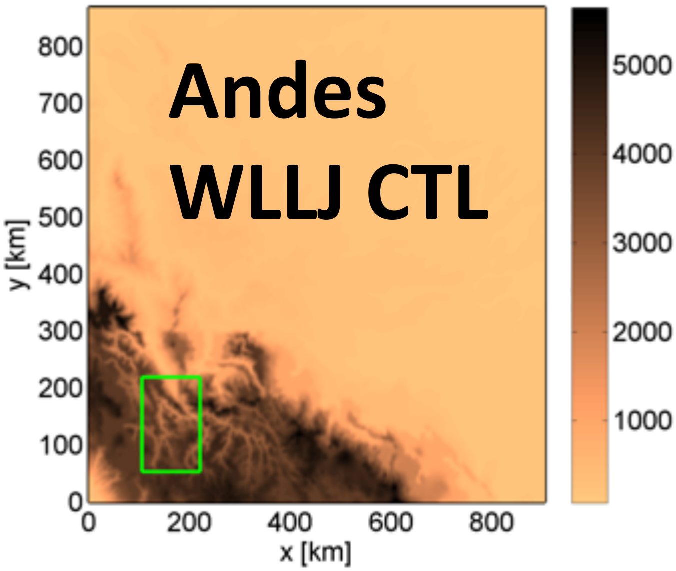
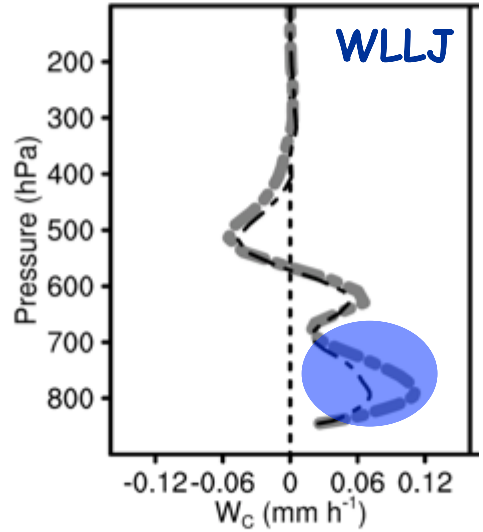
Convection diagnostics (1:00 PM, LST)

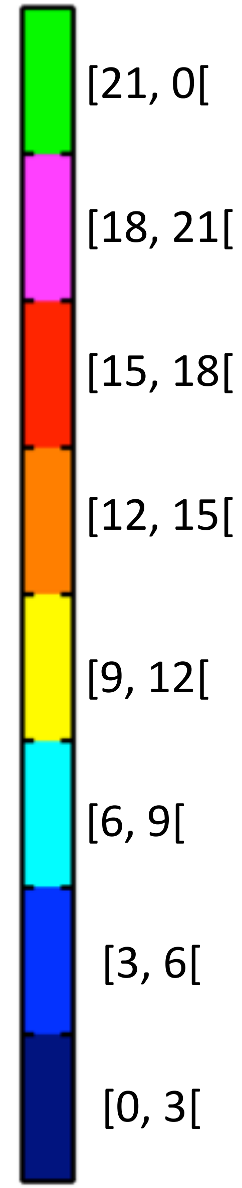




What does this mean
at the ridge-valley scale?

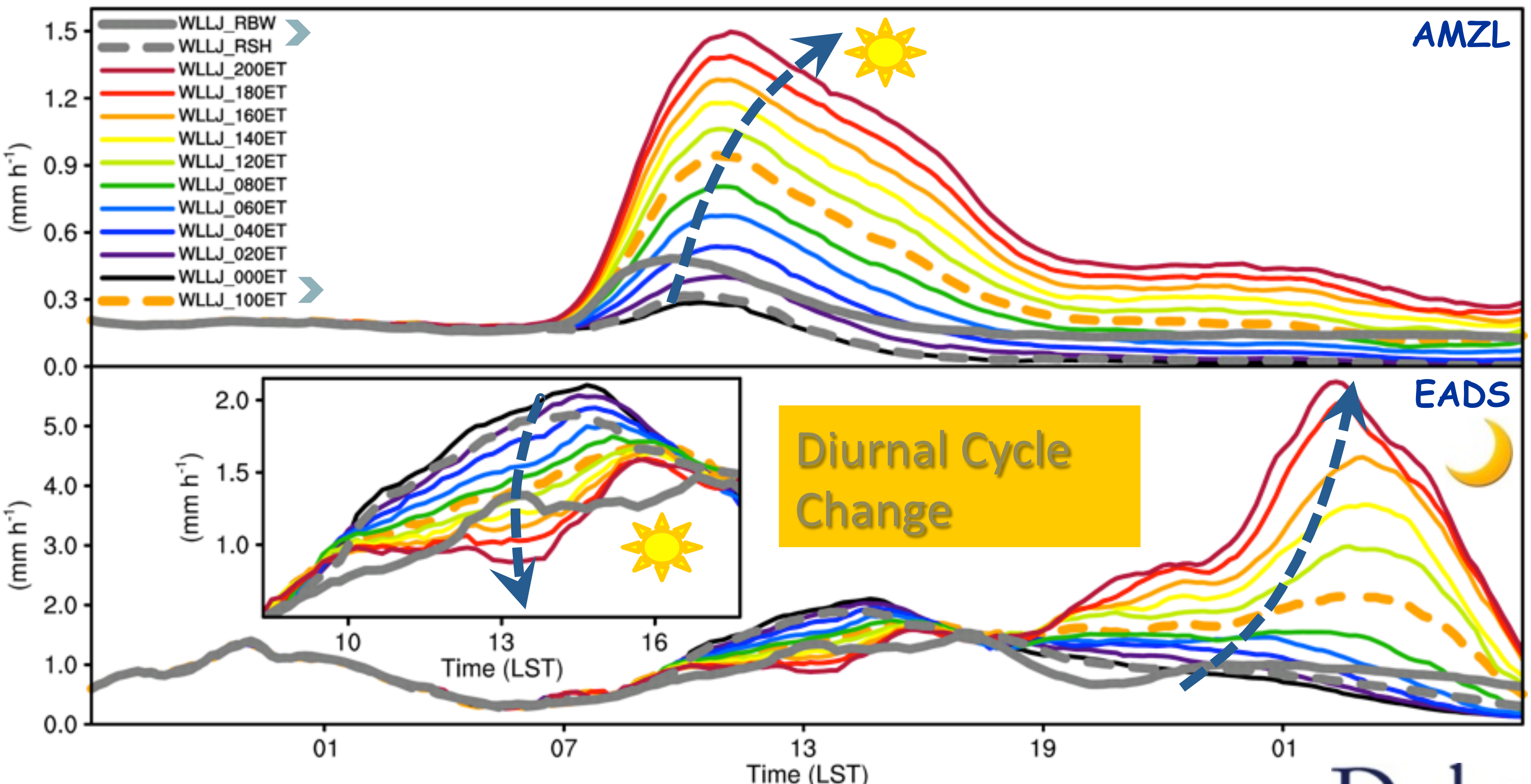






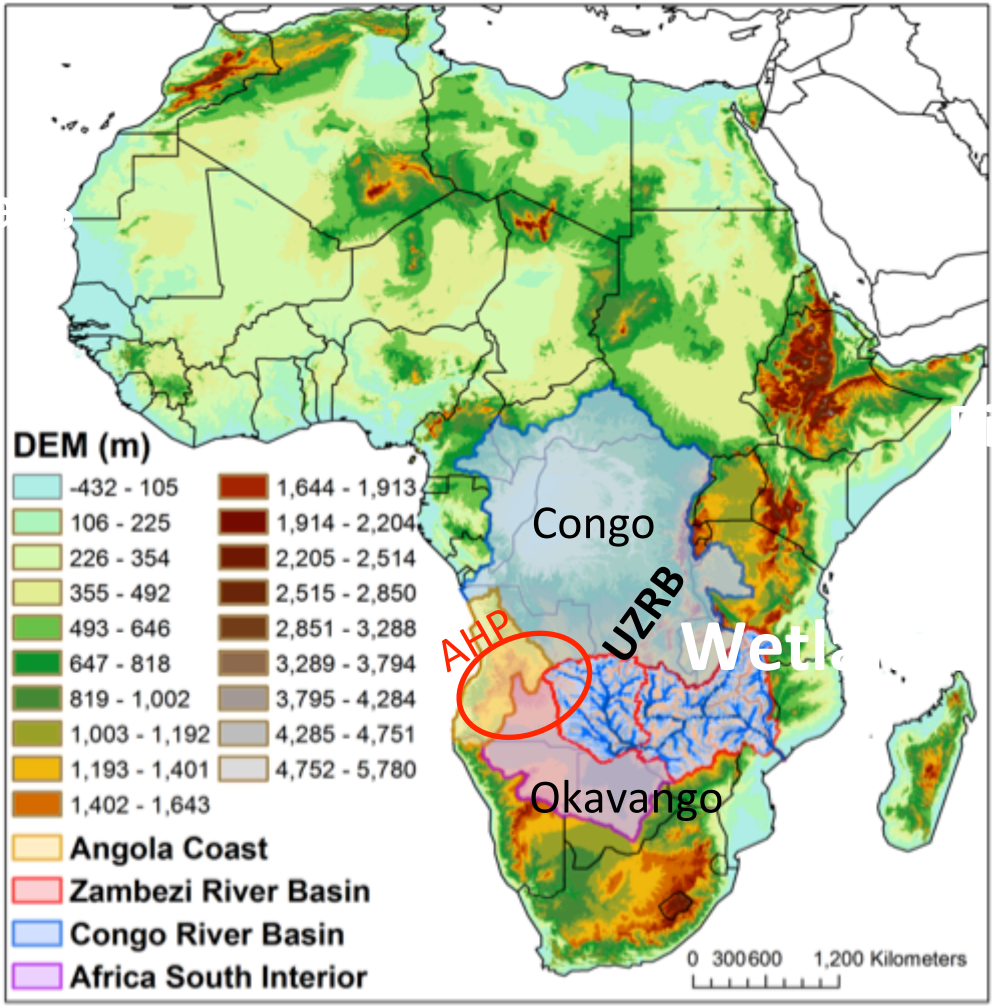
The trees are "pumping" (thermodynamically) the low level moisture that forms low level clouds and fog in the inner mountain region – *alpine pumping*

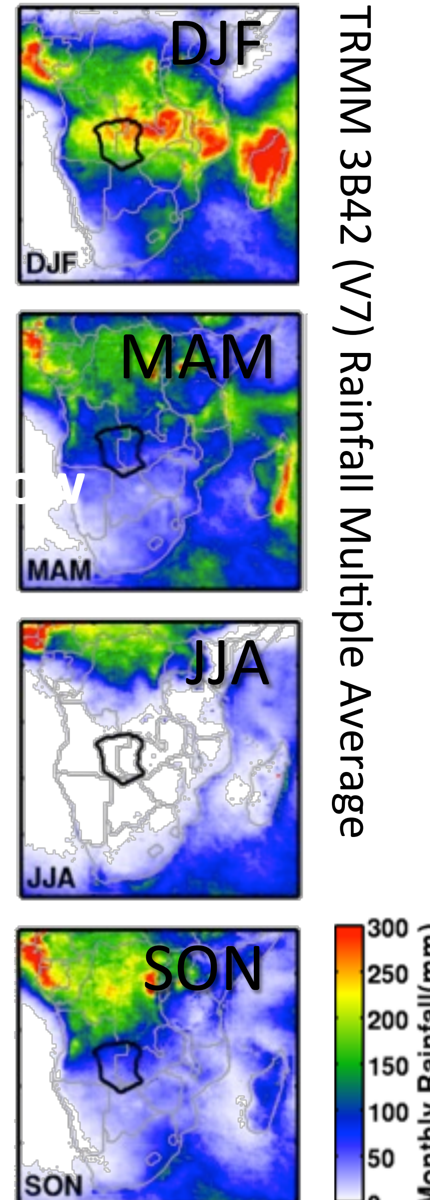
AMZL-EADS Teleconnection (D01)



Sun and Barros, QJRMS 2015

Water Resources in Southern Africa





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UZRB: Upper Zambezi River Basin

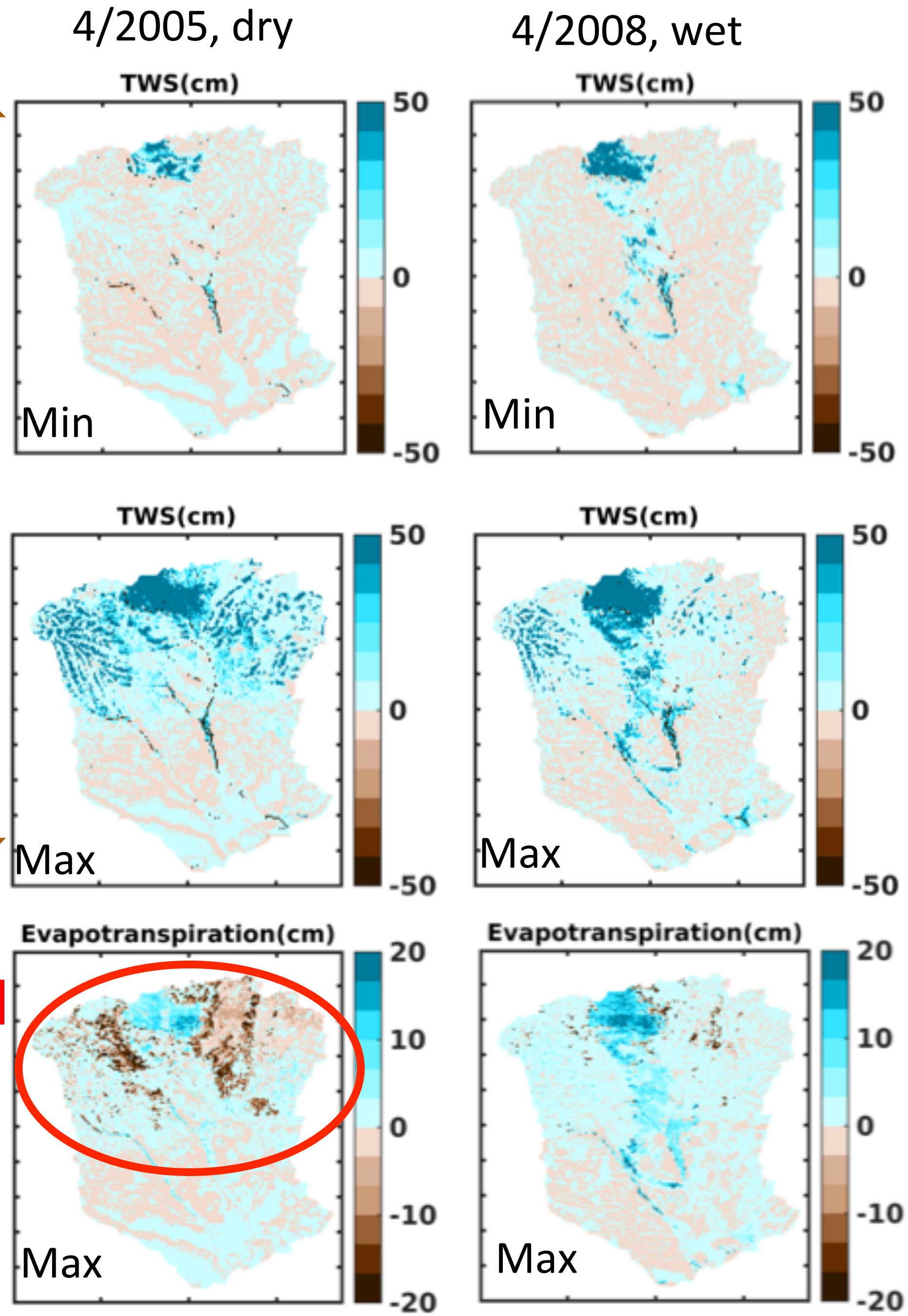
Tao and Barros, 2015

Water Balance

$P - ET - R = \Delta TWS$

With-without wetlands

Recharge Uncertainty From Wetland Mapping



Nonlinear Geospatial Uncertainty (15-30%)

Evapotranspiration Uncertainty

Ana P. Barros

NCSE 2016 Food-Energy-Water Conference , Jan 19-21 2016

Duke University

Strategy

- What do you see as the key objectives and tasks?
  - Map hypothesis-driven, process-based routes and checkpoints to address specific questions through observations and model experiments
  - Prioritize routes/systems
  - Do it
  - Recognize the difference between impact and science driven questions and develop alternative routes with common checkpoints
  - Do both
  - Welcome Surprises
  - Critical Mass

- ❑ And which resultant social, economic,and/or environmental benefits justify the associated capital investment?
  - ❑ Consumptive Water Use (Humans and Ecosystems)
  - ❑ Conservation in the Homeland
  - ❑ Engineering the Future
  - ❑ Food_Water_Energy_Climate Nexus
- ❑ Any other issues you feel are critical.