Assessing the role of land surface hydrology in the development of terrain-induced convection

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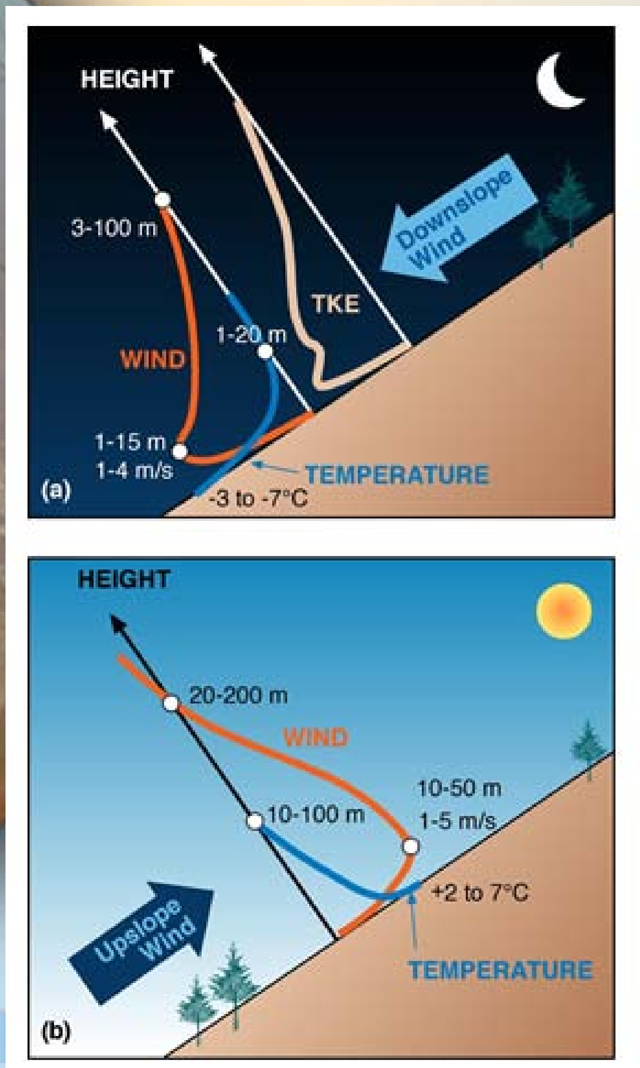
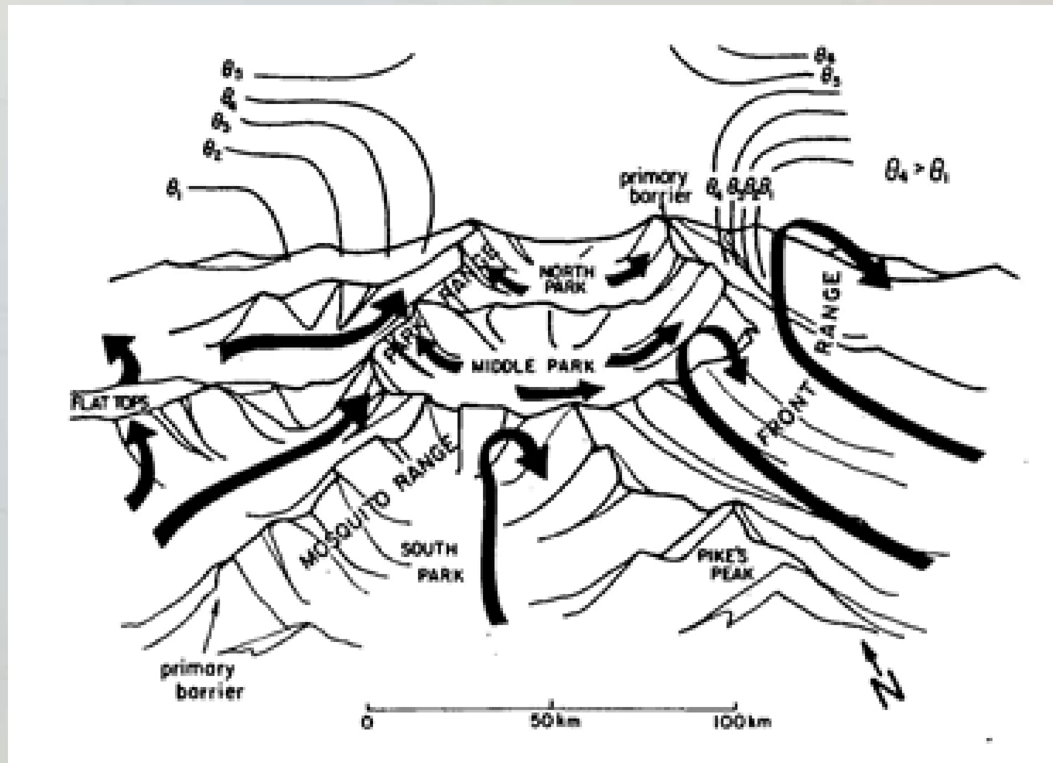
Thermally-forced terrain circulations…

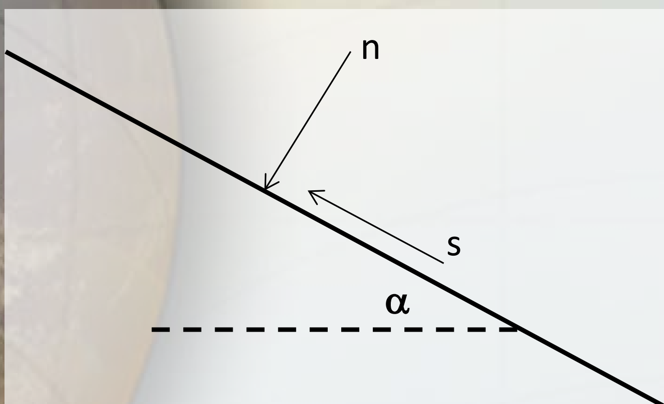




Images courtesy Zardi and Whiteman, 2012

Background: Terrain circulations…

- Formalization:



Local Press. Perturbation

Buoyancy-reduced Gravity

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial s} + w\frac{\partial u}{\partial n} = -\frac{1}{\rho_0}\frac{\partial(p - p_a)}{\partial s} - g\frac{d}{\theta_0}\sin\alpha - \frac{\partial\overline{u'w'}}{\partial n}$$

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial s} + w\frac{\partial w}{\partial n} = -\frac{1}{\rho_0}\frac{\partial(p - p_a)}{\partial n} + g\frac{d}{\theta_0}\cos\alpha$$

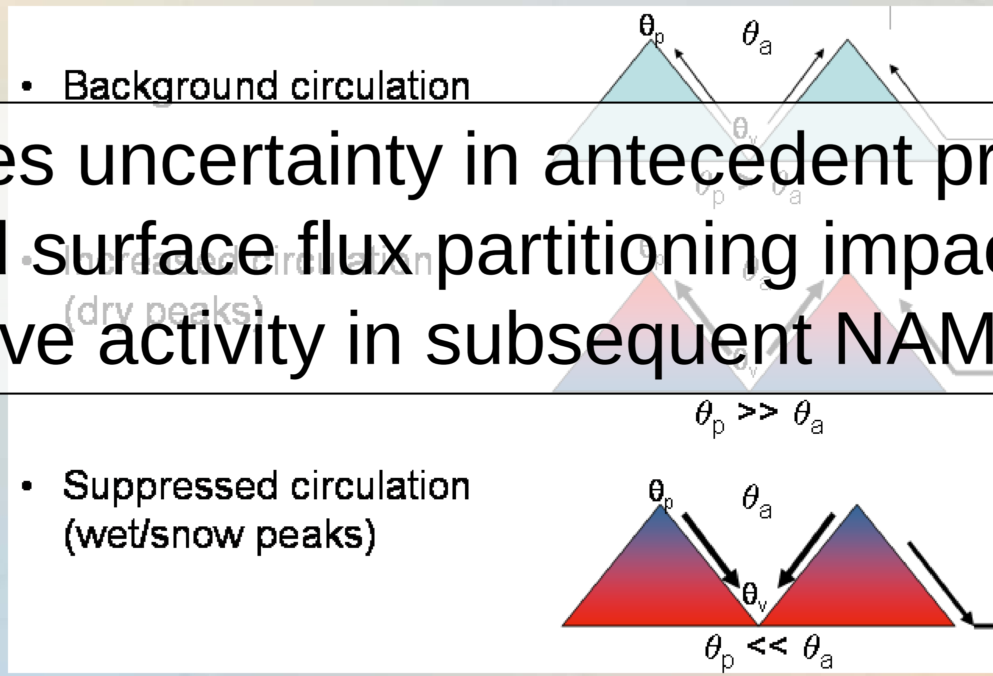
$$\frac{\partial \theta}{\partial t} + u\frac{\partial \theta}{\partial s} + w\frac{\partial \theta}{\partial n} = -\frac{1}{\rho_0 c_p}\frac{\partial R}{\partial n} - \frac{\partial\overline{w'\theta'}}{\partial n}$$

Sensible Heat Production

$$\frac{\partial u}{\partial s} + \frac{\partial w}{\partial n} = 0$$

Questions and Hypotheses:

1. How do the ‘super-position’ of sfc energy fluxes influence on thermal circulation regimes…



How does uncertainty in antecedent precipitation and land surface flux partitioning impact convective activity in subsequent NAM forecasts?

2. What role does ‘landscape-scale’ hydrology have on modulating surface fluxes?

Motivation:

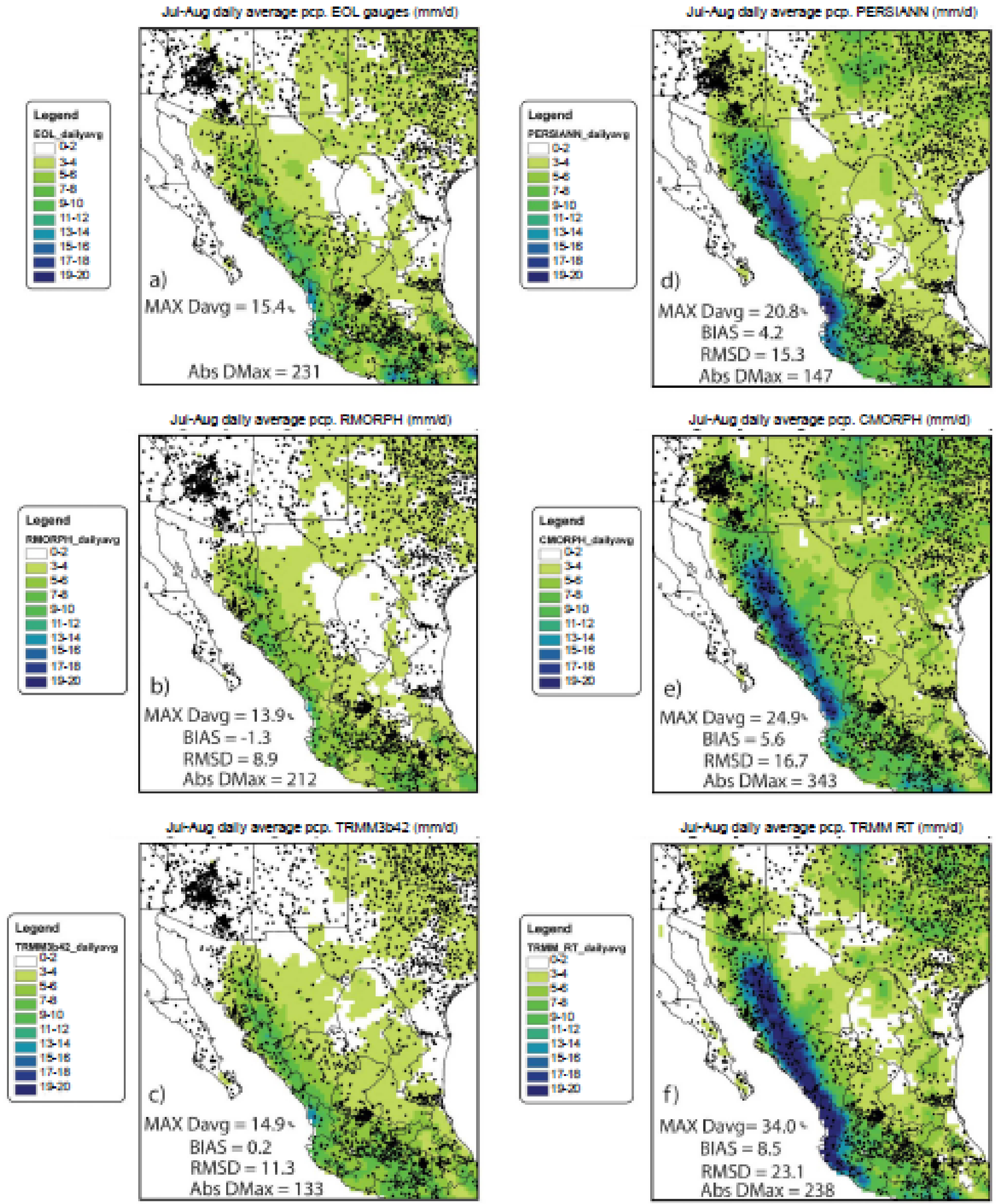


Fig. 5. Comparison of 2004 Jul-Aug daily mean rain rates (mm/d) from a) NAME/EOL gauge data, b) RMORPH, c) TRMM 3b4.2v6, d) PERSIANN, e) CMORPH and f) TRMM_RT.

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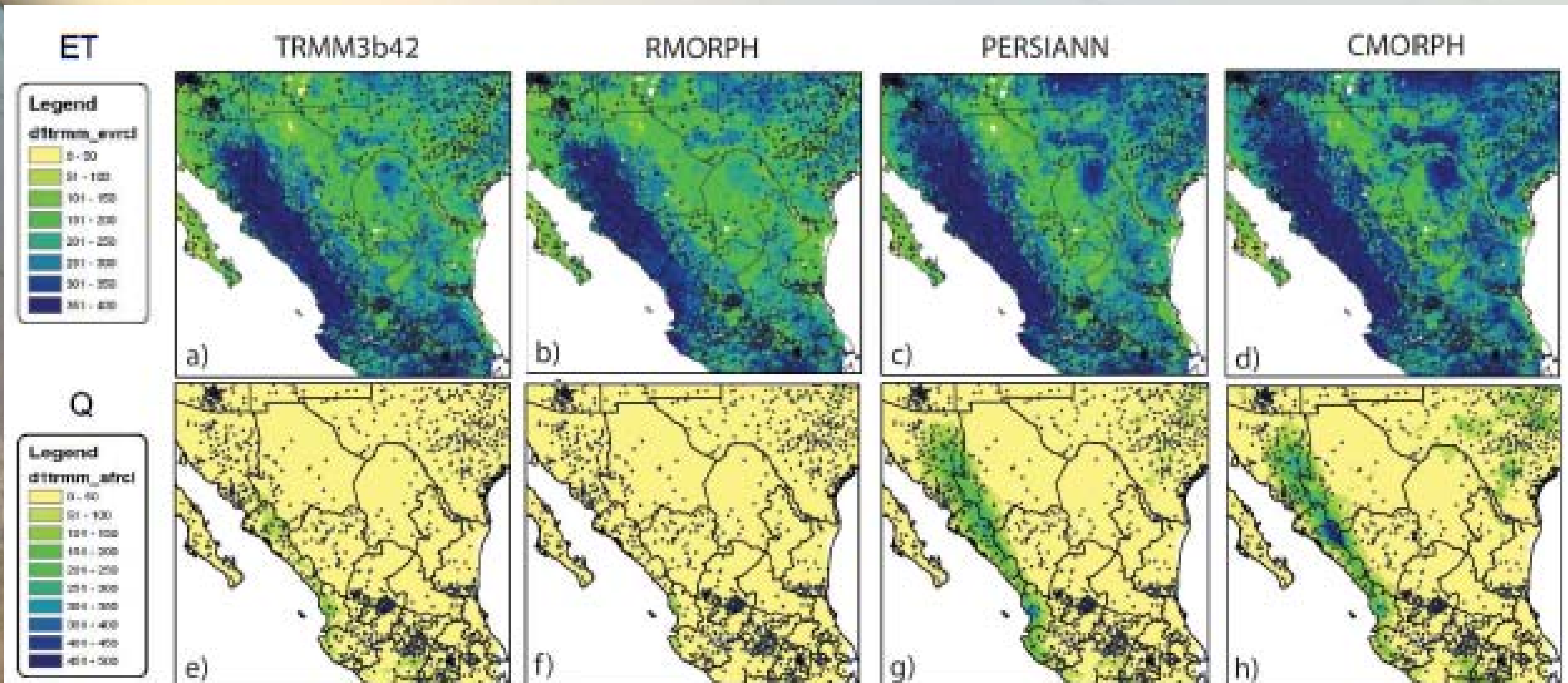
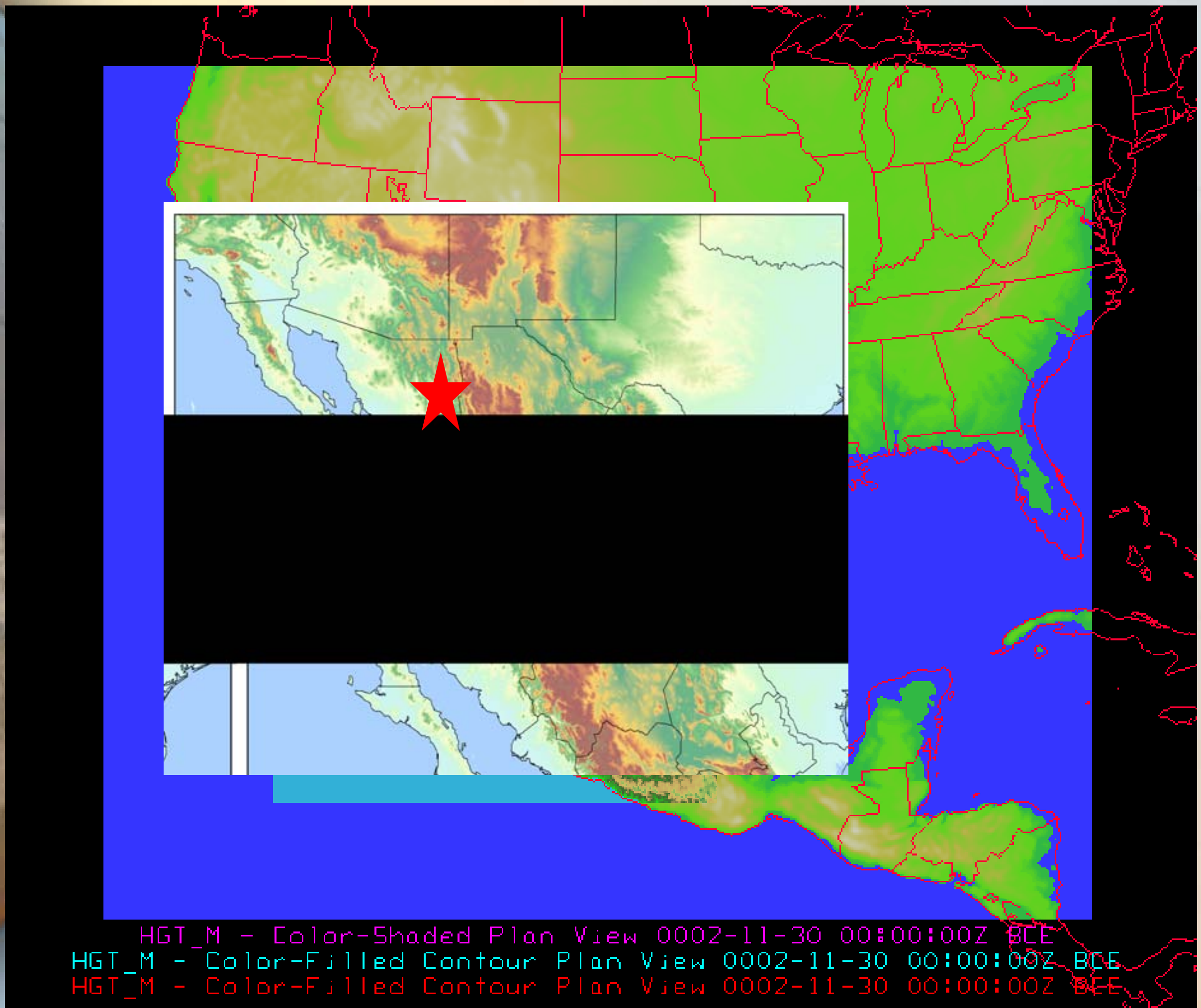
Motivation:



Gochis et al., 2008 Atmosfera

Experimental Design:



Goals:

1. Diagnose controls on land-sfc-fluxes

2. Assess impact of local fluxes on PBL-CI behavior (model-based)

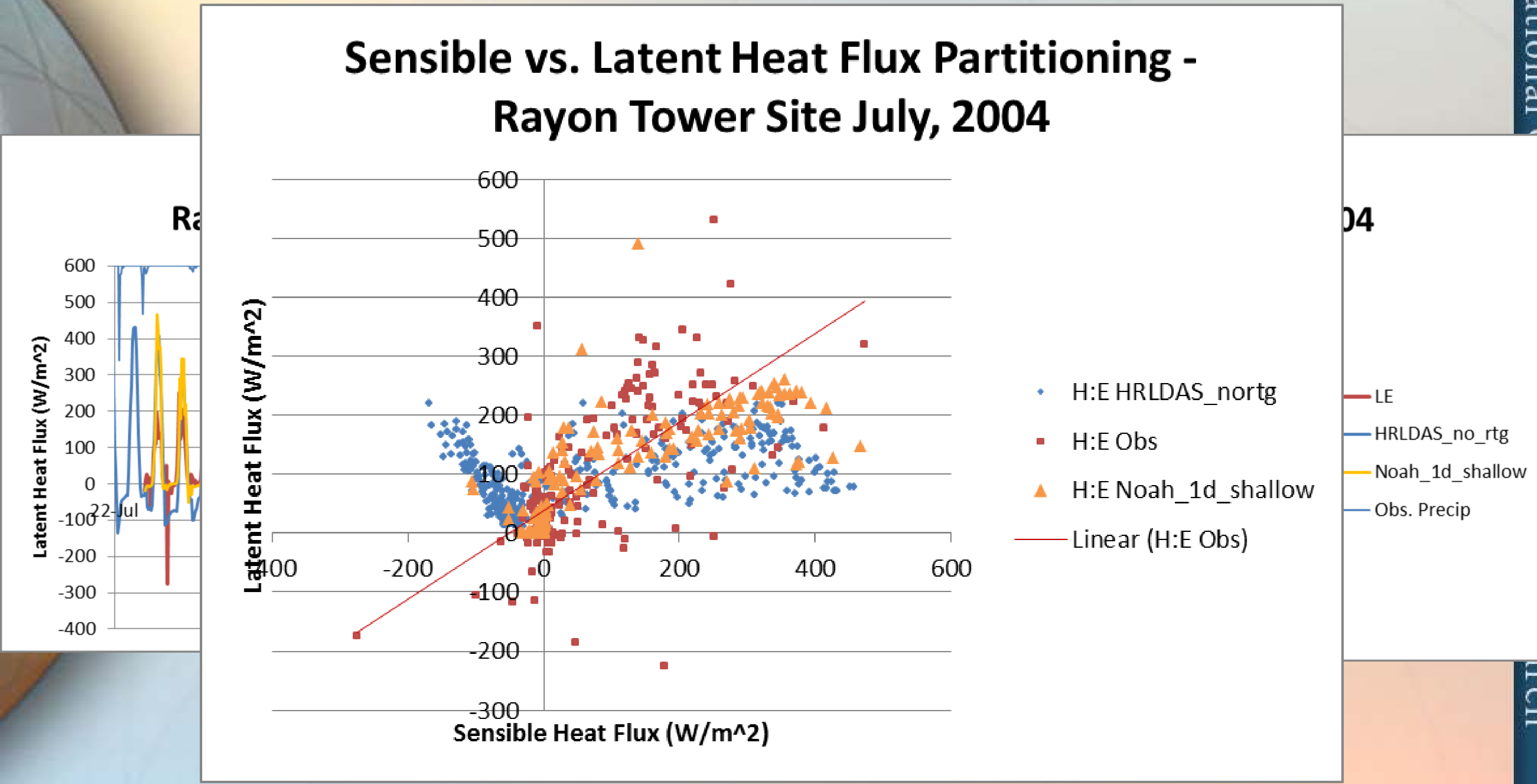
3. Define the role of land-sfc fluxes on multi-day forecasts

Experimental Design:

1. 1-d land surface model studies on model forcings

2. 3-d WRF diurnal cycle initialization experiments

Offline evaluation of Noah LSM Surface Fluxes:



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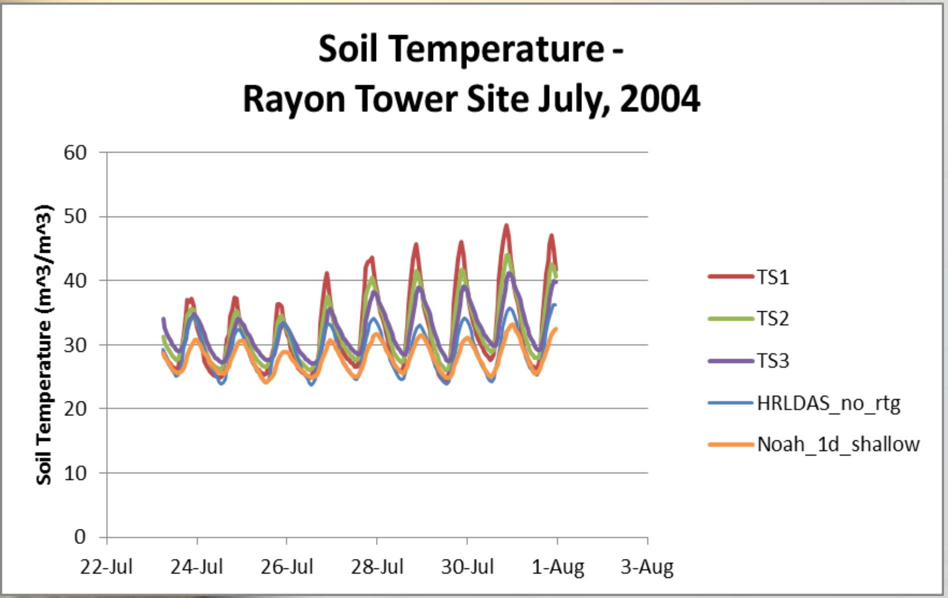
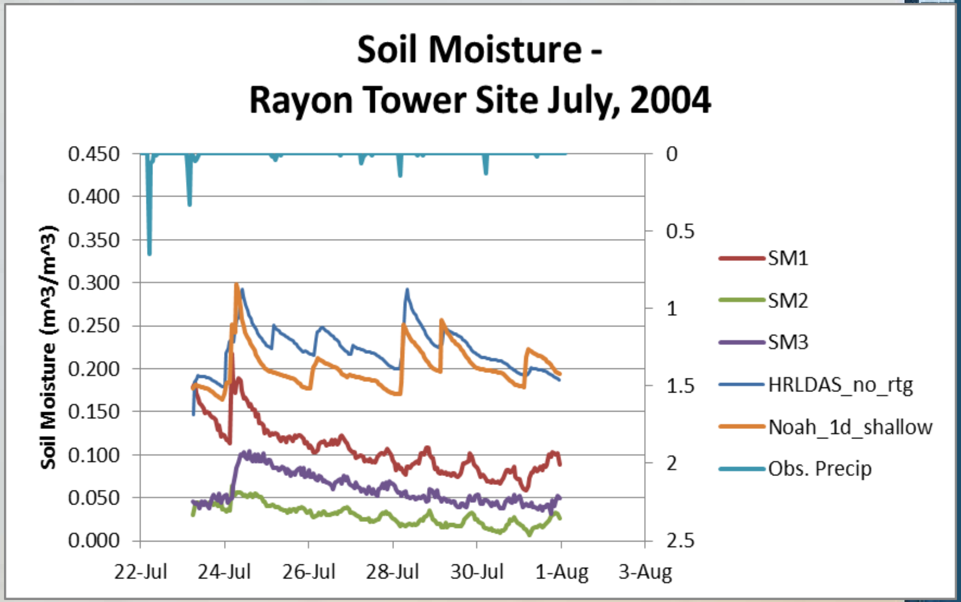
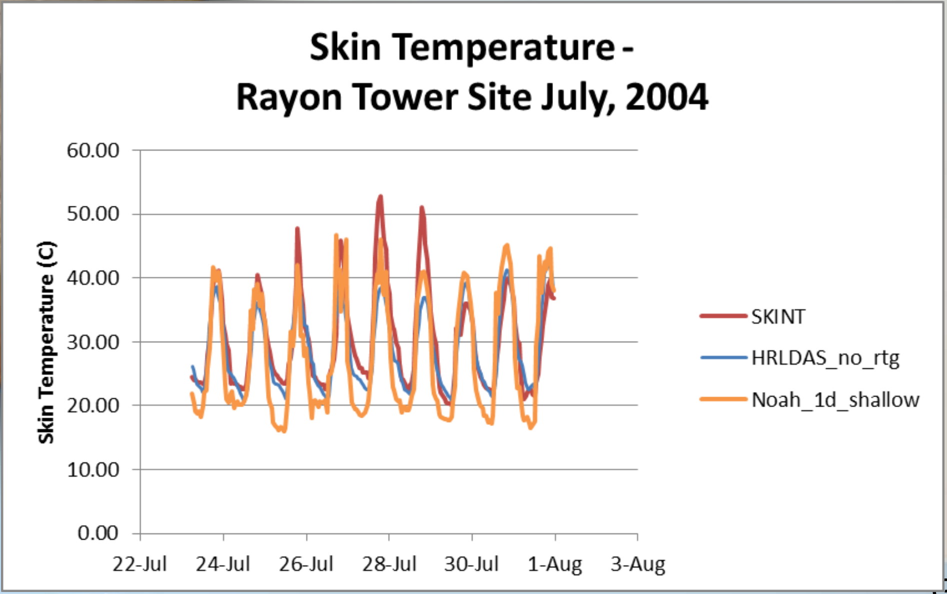
Gochis et al., VAMOS Modeling Workshop, Petropolis Brazil 2012

Offline evaluation of Noah LSM Surface Fluxes:







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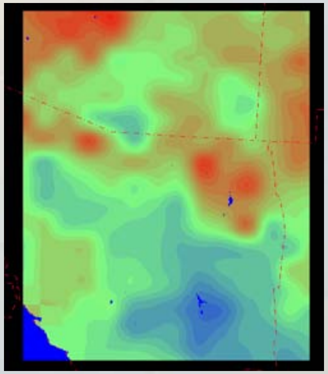
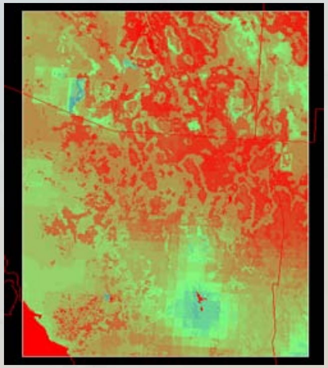
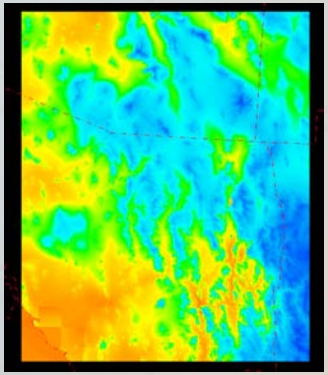
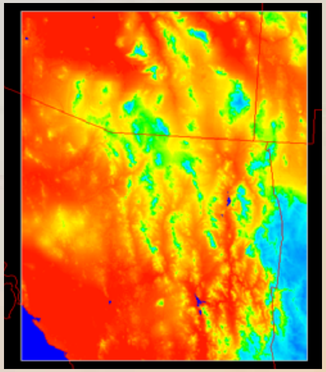
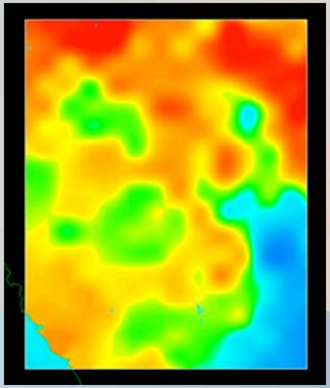
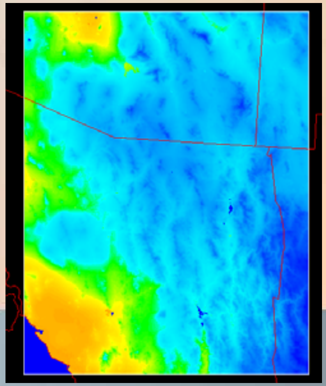
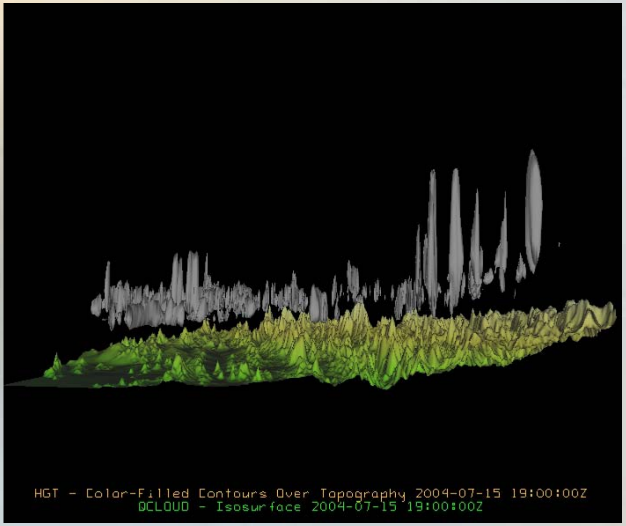
Coupled WRF Model Configuration & Experiments:

- Dates: 1 Diurnal Evolution… 12-24z Jul. 15, 2004
  - ‘Typical’ monsoon day following ‘active’ period but no significant dynamical forcing
- Configuration:
  - Single 1km domain, NARR Init./L.B.C
  - No Cu-Parm, YSU-PBL, M-O Sfc. Layer, Thompson Microphys.
  - Slab & Noah-LSM
- Initializations:
  - Slab model – Water availability factor as f(Landuse)
  - North American Regional Reanalysis
  - 18month HRLDAS driven by NLDAS2 (w/out routing extensions)

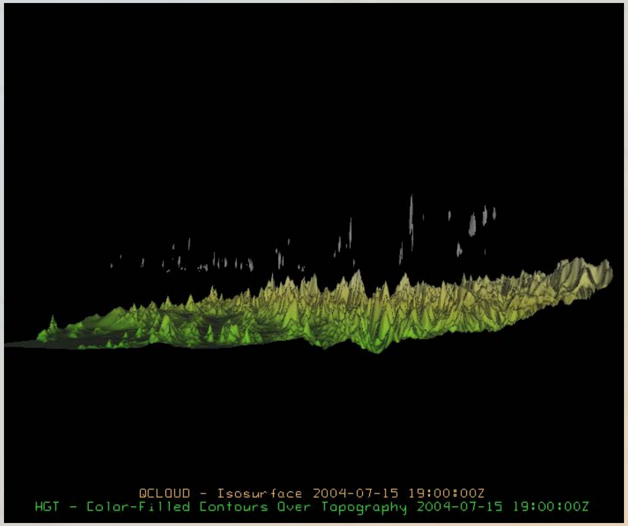
Land Surface Spin-up/Initialization Evaluation: 1200z

	NARR Init	NOAH_NORT
Soil Moisture (.05 – .45)		
Soil Temperature (280 – 305)		
Skin Temperature (280 – 305)		

WRF Model Evaluation: by 1900z

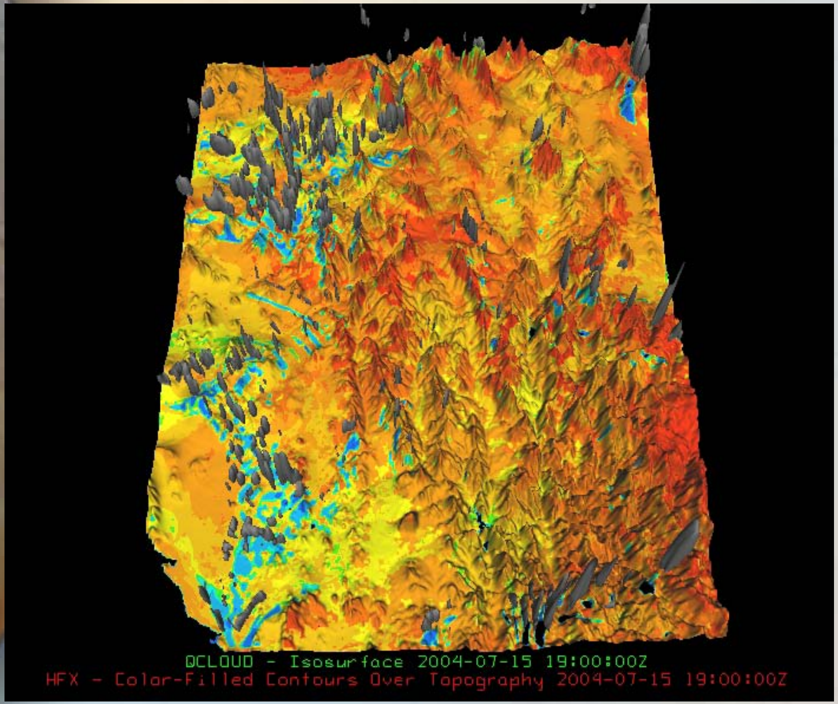


Noah-NARR init.

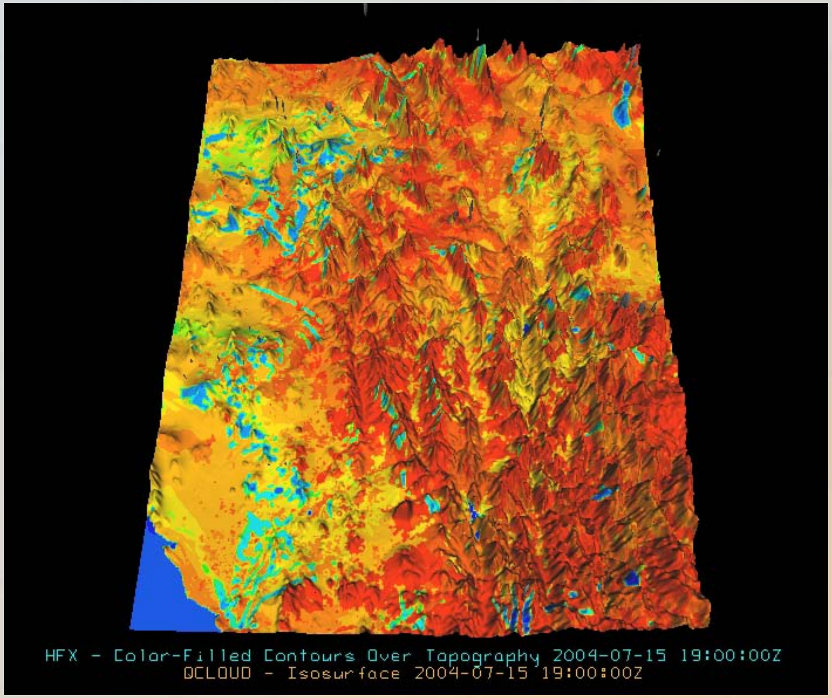


Noah-HRLDAS init.

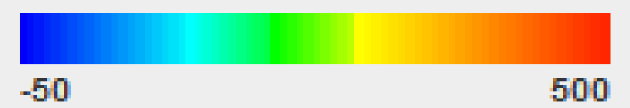
SENSIBLE HEAT FLUX (19z)



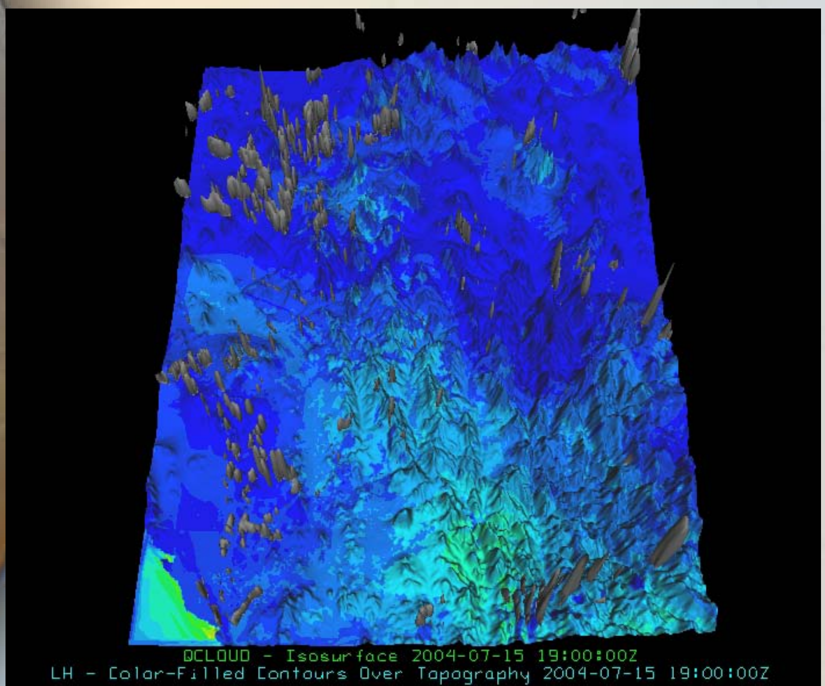
Noah-NARR init.



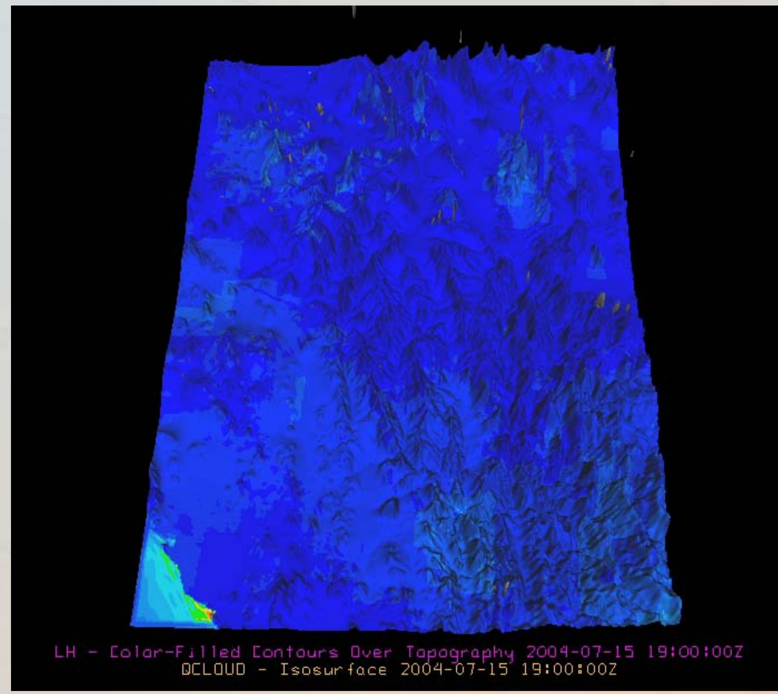
Noah-HRLDAS init.



LATENT HEAT FLUX (19z)



Noah-NARR init.



Noah-HRLDAS init.

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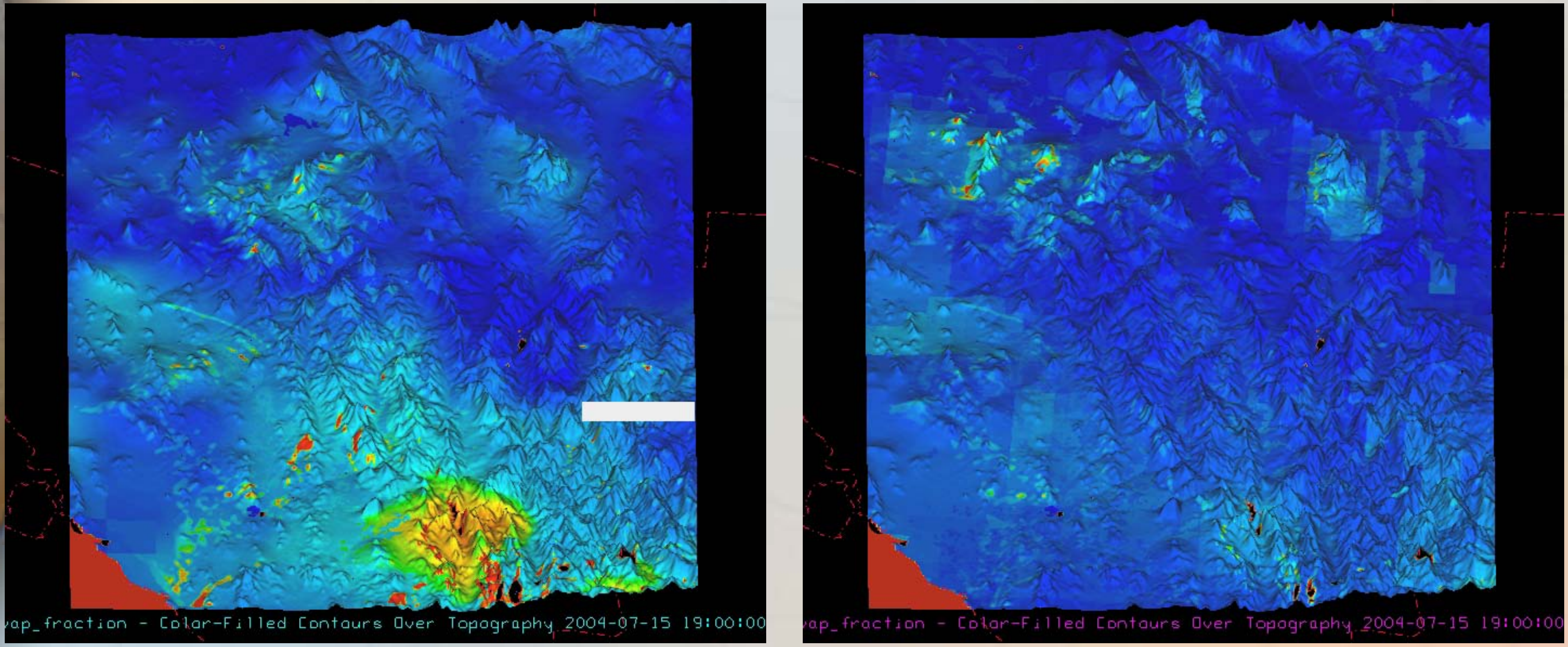
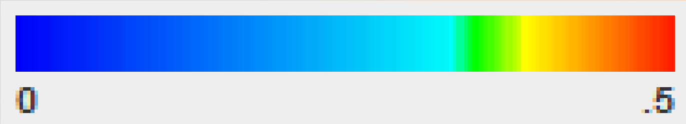
Evaporative Fraction (19z)



Noah-NARR init.

Noah-HRLDAS init.



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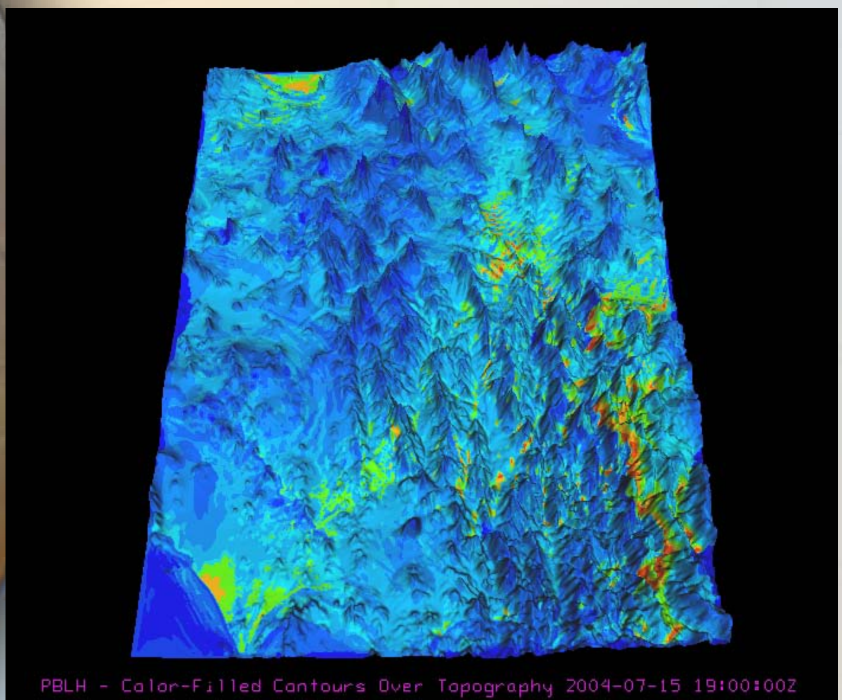
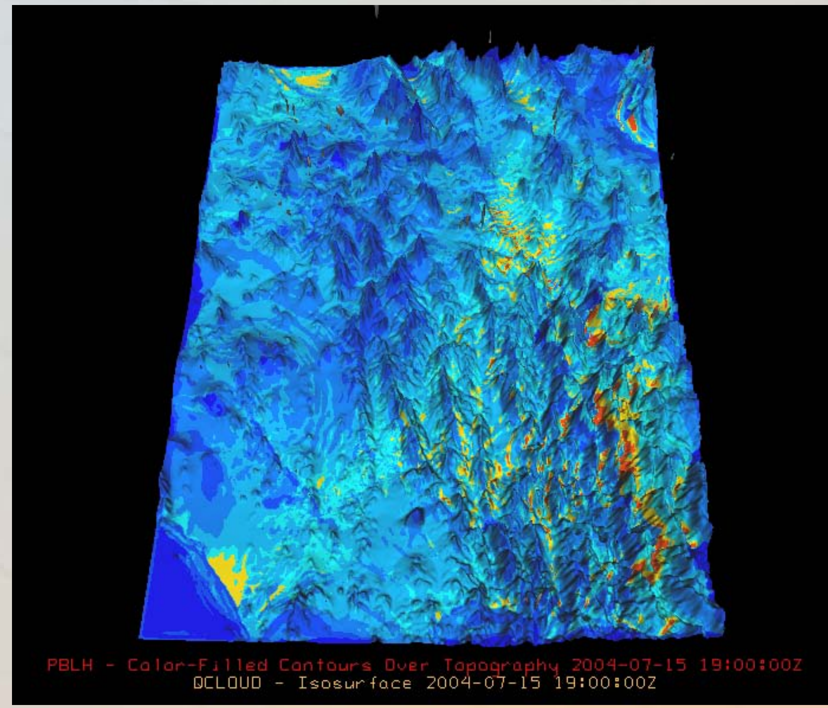
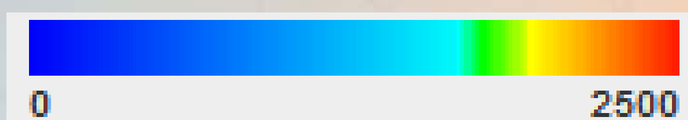
PBL HEIGHT (19z)



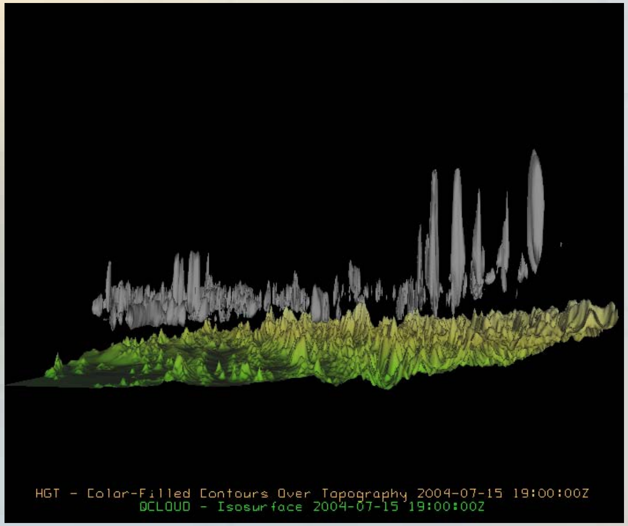
Noah-NARR init.



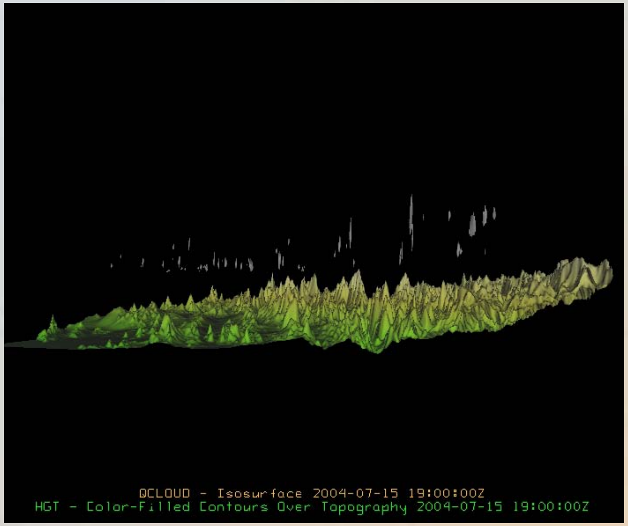
Noah-HRLDAS init.



WRF Model Evaluation: by 1900z



Noah-NARR init.



Noah-HRLDAS init.

Conclusions:

- Land model structure and initialization has pronounced influence diurnal evolution of surface fluxes, PBL growth, and clouds in the N. Am. Mon.:
  - Dry/hot Noah-HRLDAS shows high H and low LH w/ little cloud (pos. ‘dry’ feedback)
  - Moderate NARR init. produces comparatively greater sensible heat flux heterogeneity, greater PBL height variability and more cloud (‘mixed’ regime)
- Biases in precip. analyses used in data assimilation may play a critical role in limiting prediction skill
- In regions and flow regimes where coupling is ‘strong’ the findings suggest it is important to properly capture local energy partitioning