The G3scheme: An improved ensemble scheme with an option for high resolution (“gray scales”) applications

Georg Grell
NOAA / Earth Systems Research Laboratory

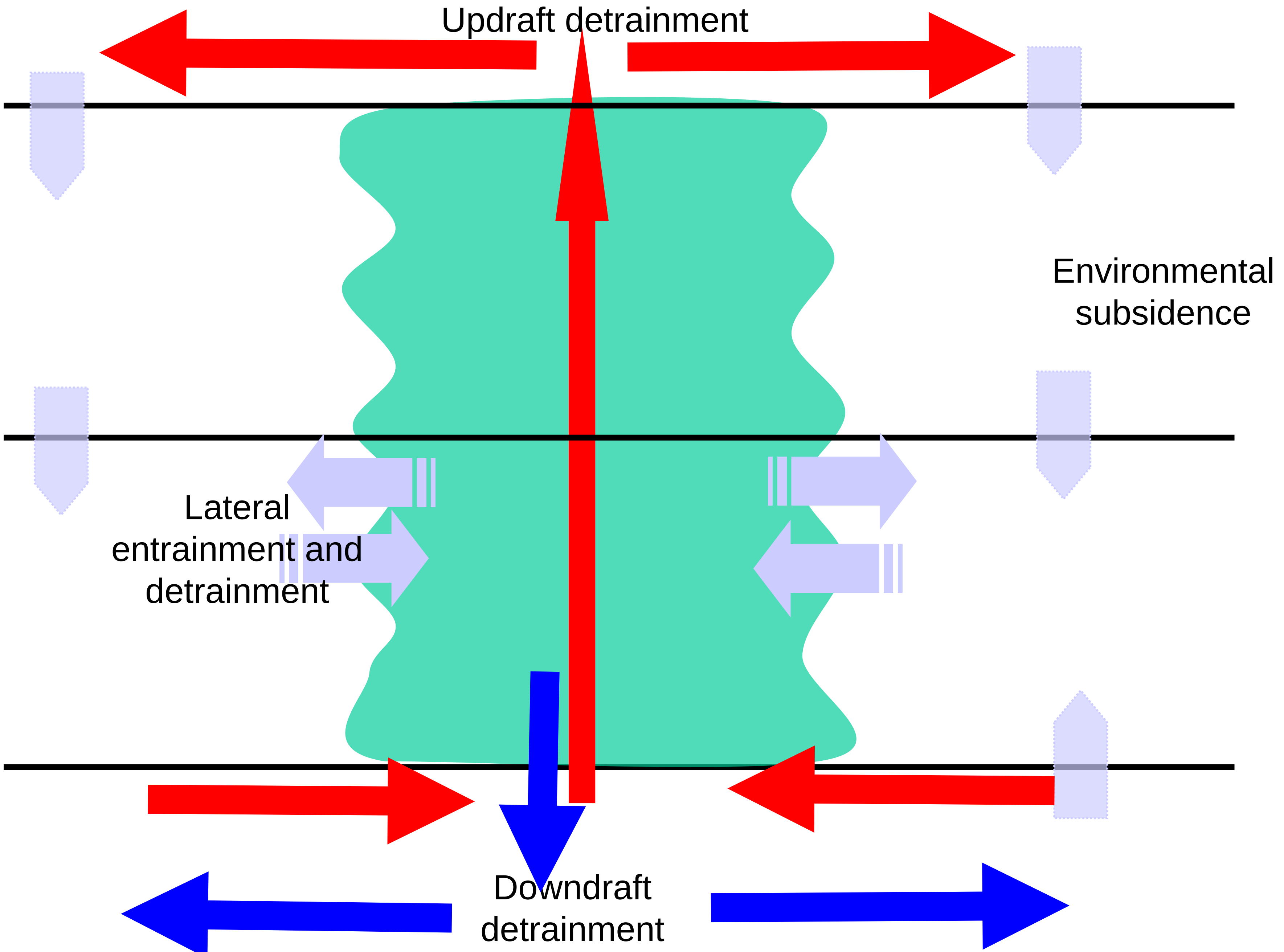
Major contributors: Dezso Devenyi, Mariusz Pagowski, Evelyn Grell

A thank you to AFWA for providing some seed money to work on the GD scheme

Structure of talk

1. Some improvements and capabilities of older scheme (turns GD into default G3 scheme)
2. G3 with subsidence spreading over neighboring grid points
3. PDF's for heavy precipitation likelihood

Usually: One Grid Box



GD and G3 are ensemble schemes

Ensembles in GD consist purely off various closure assumptions or trigger functions used by various convective parameterizations

“Closures” within GD (assumptions that regulate the amount and location of parameterized convection

- Integrated vertical advection of moisture (Krishnamurthi)
- Low level vertical velocity (Brown or Frank and Cohen)
- Removal of instantaneous stability (like KF)
- Dependence on destabilization (old grell)
- Dependence on destabilization (as in GFS version of my old scheme)

Triggers within GD and G3 used as an ensemble (important for location of convection):

How thin must the "cap" be before convection can poke through?

trigger ensemble for every closure

Possible ensemble feedback assumptions

- ~~Radius (size) of clouds, entrainment~~
- ~~Detrainment from updraft (stability dependent)~~
- Wind shear dependent precipitation efficiency (dependence of downdraft strength on updraft strength)

Our experience with the ensemble scheme (GD) within WRF when looking at each ensemble separately (but when run together):

- The solutions sometimes appeared lopsided (aliased towards one closure). One closure always the largest rainfall, one always the smallest (this does not happen if running completely separate)
- Appeared caused by stability closures
  - By adjusting to a climatological value ("0" or climatological cloud work function), one was always favored over the other
  - Changing the absolute values of these CWF's did not change things, it just shifted (a closure that previously led to always small rain rates, now led to largest rain fall rates)

Change in “closures”

- Remove AS closure as it is implemented in the GFS (remove CAPE to a certain climatological value), but leave in the total removal closure and the “old grell”
- Add an ensemble to look at the min/max/average values of the other ensembles within the nearest neighbor grid points (could be nine or 25 grid points)
- Add a random number generator to arbitrarily pick some ensemble values out of the “pack” (this is currently turned off in V3, because we do not have a “good” random number generator

<u>This constitutes the basic G3 scheme</u>

The not so basic G3 scheme

The G3 scheme has two additional features that may be turned on or off:

- Horizontal and vertical smoothing of tendencies (is turned on by default)
- A three-dimensional application of the feedback to the model

Why 3-d application?

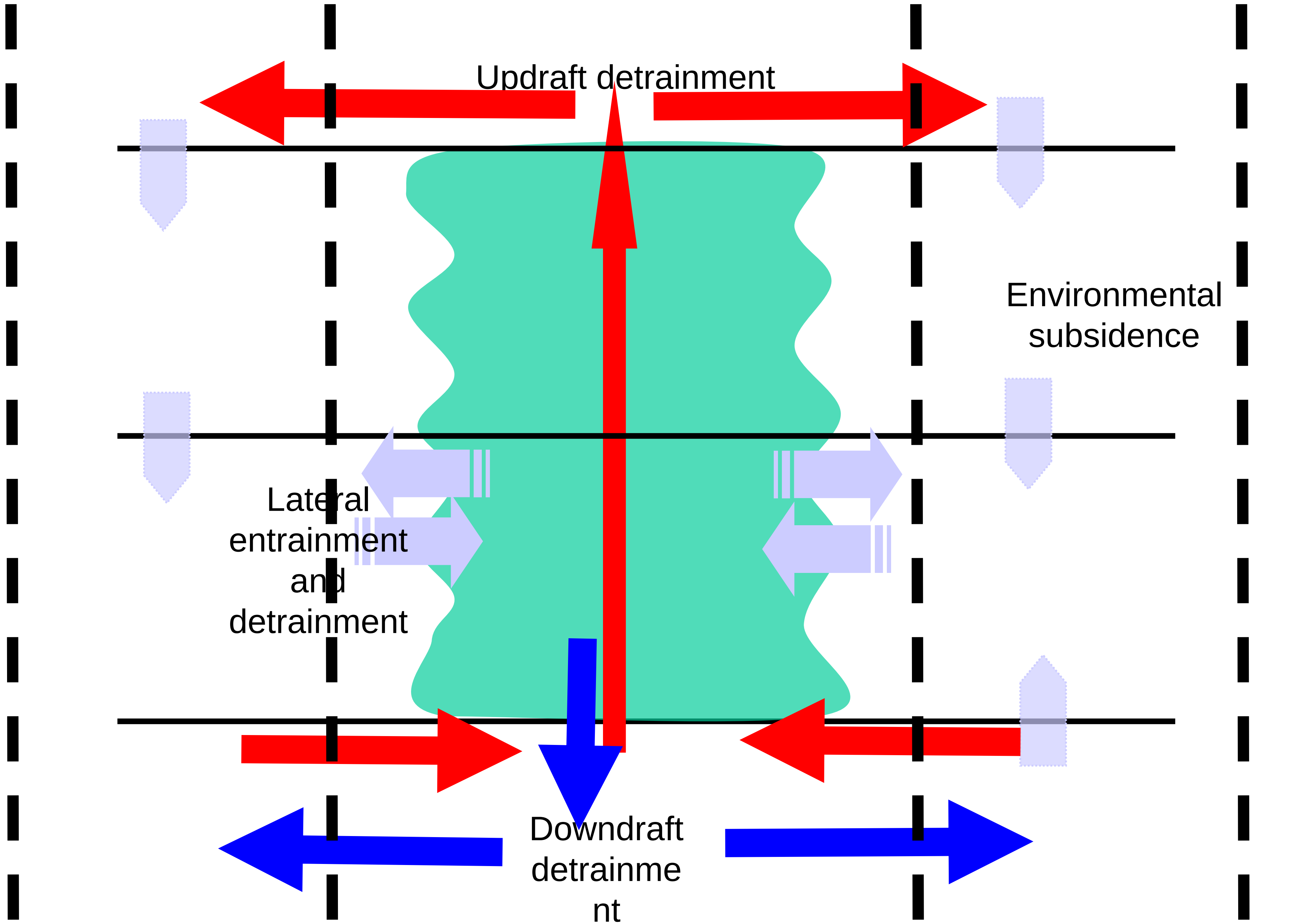
Gray scales: scale separation
Two main Problems

- Model may try to simulate the already parameterized process explicitly
- Parameterization may try to parameterize a process that the model may be able and **was supposed to simulate** explicitly
  - Subsidence dries too much! Very bad!

Why 3-d application?

- To allow for a smooth transition on “gray” scales, where more and more of the convection is resolved (should be resolved!!)
  - On scales of dx 5km to 20km, the explicit microphysics scheme has a hard time taking over when the convective parameterization has strong subsidence heating and drying all ocurring in one grid box (the flow is almost too “viscous” with respect to explicit convection
- This is a somewhat different approach than what is done for example by UKmet office, which lets the resolved numerics do all the subsidence
  - As a first choice, I did not like that approach because of mass conservation fear (especially for tracers)

G3: nine or more grid boxes



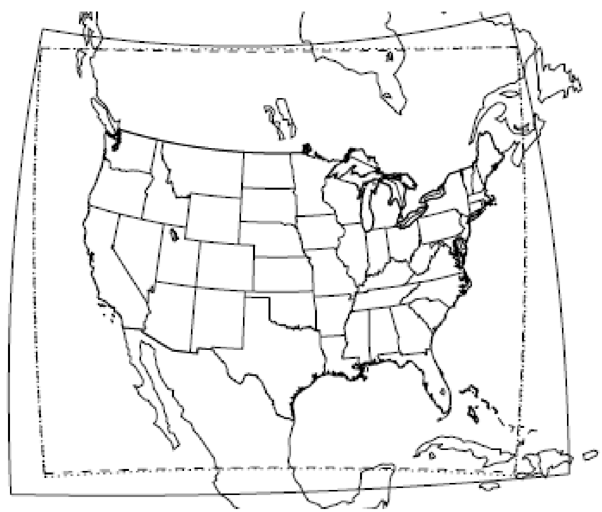
G3:what about the effect of cugd_avedx:

Cugd_avedx is the number of grid points that are affected

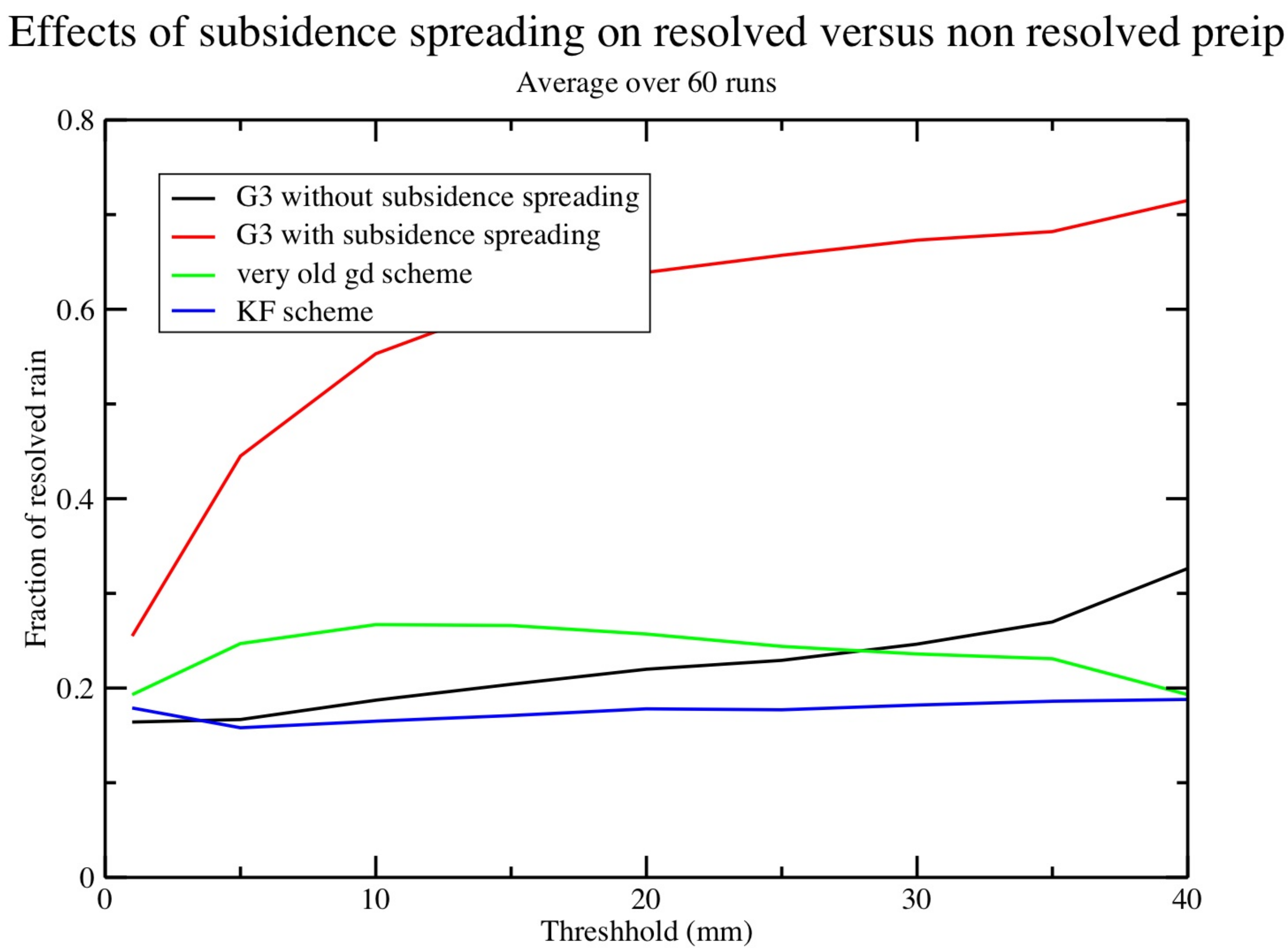
- As of now: only works for cugd_avedx=3 (subsidence is spread over nine grid boxes)
- Inner most box only experiences lateral entrainment/detrainment
- In near future: linear (smooth) transition of what part is spread in what box
- In near future we will also implement cugd_avedx=5 (25 gridbox spreading)
- Mass conservation can easily be guaranteed

Use “core comparison” test bed data set and test with ARW WRF

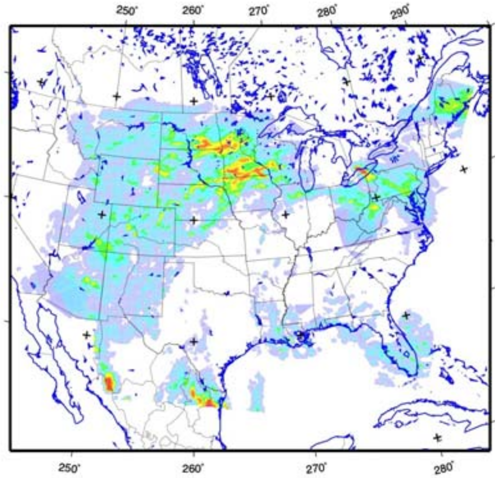
- Data set (1-month worth of 60 runs) was used to compute statistics and compare ARW and NMM cores within WRF
- CONUS grid with 12km resolution
- 24hr accumulated precipitation data based on rain gauge and radar analysis



Fraction of modeled precipitation that is resolved over all runs!

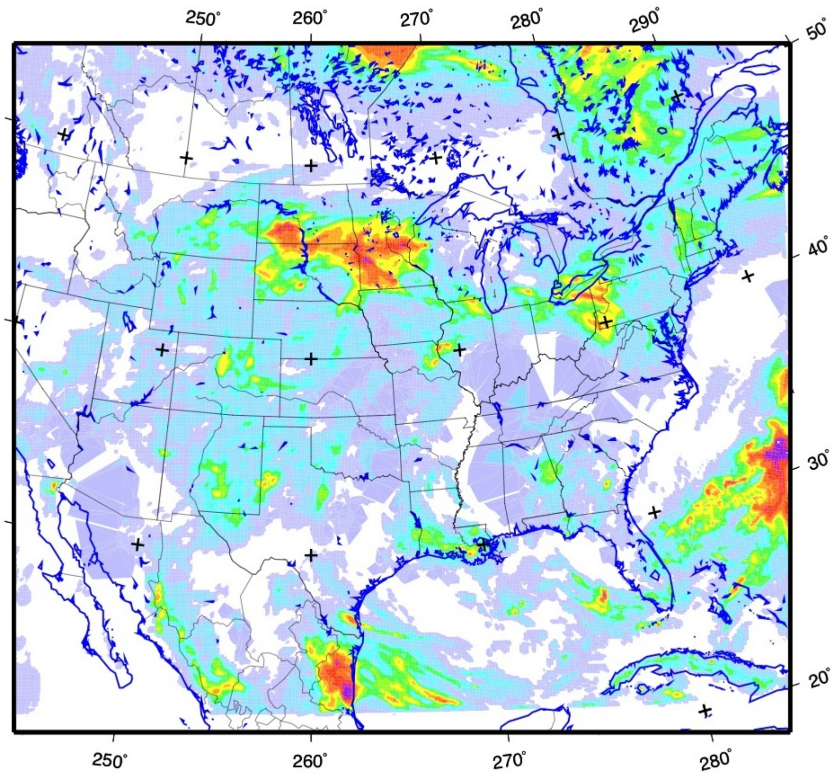


24hr accumulation at 07-26-00

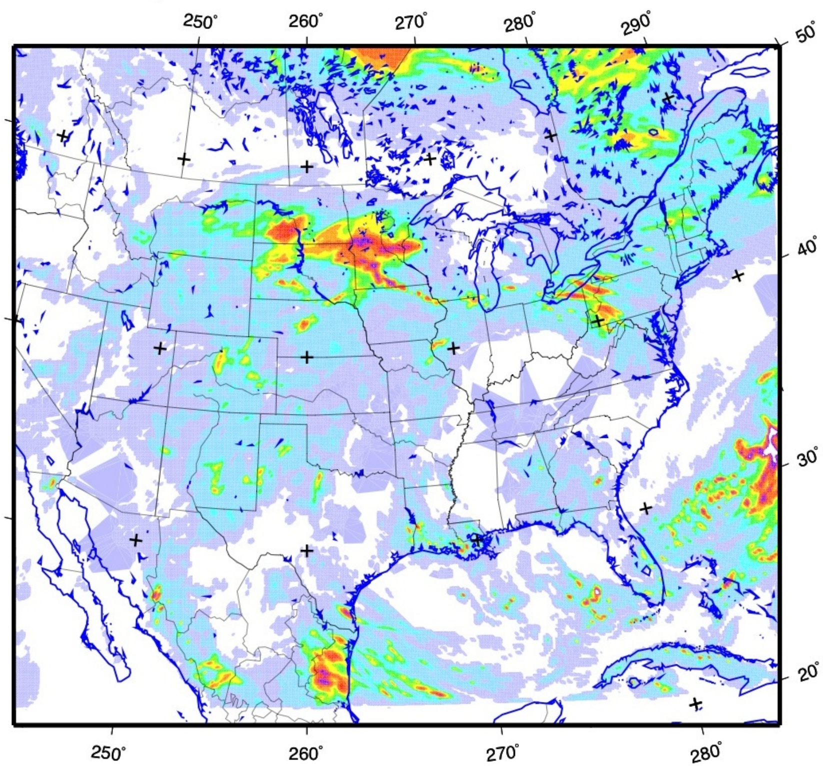


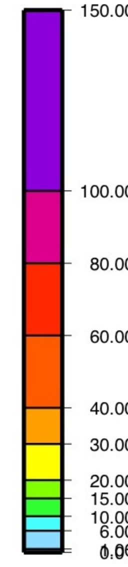
OBS

G3, no spreading

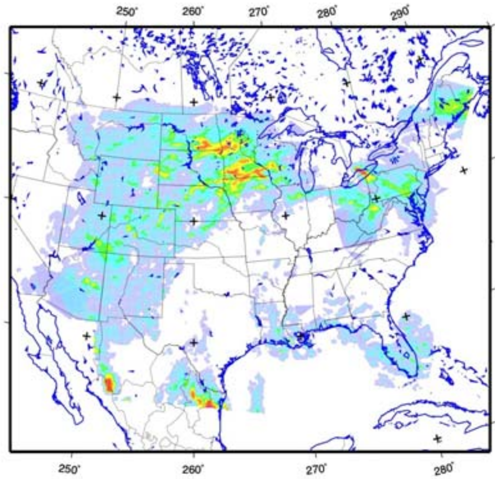


G3, with spreading



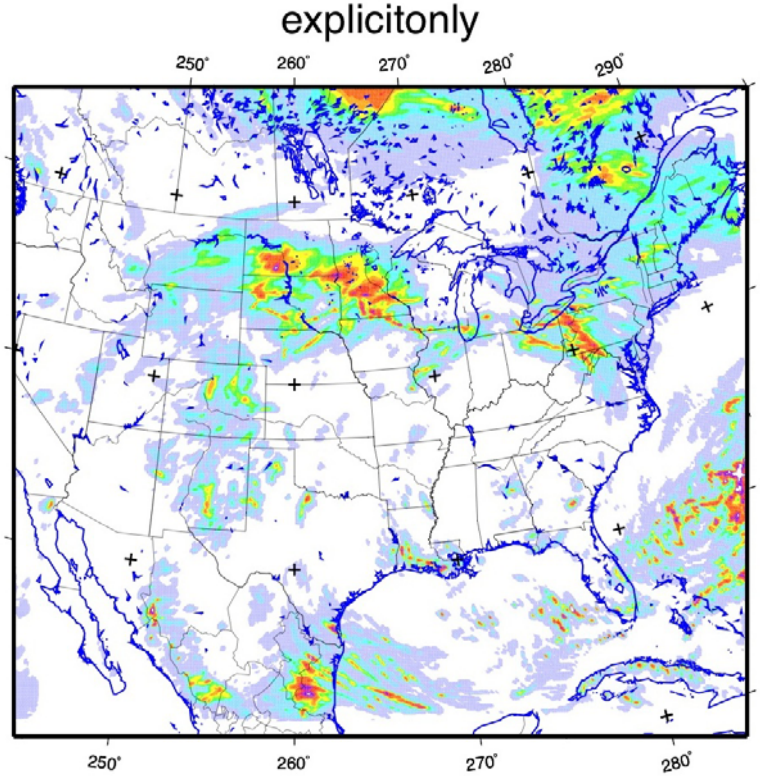


24hr accumulation at 07-26-00

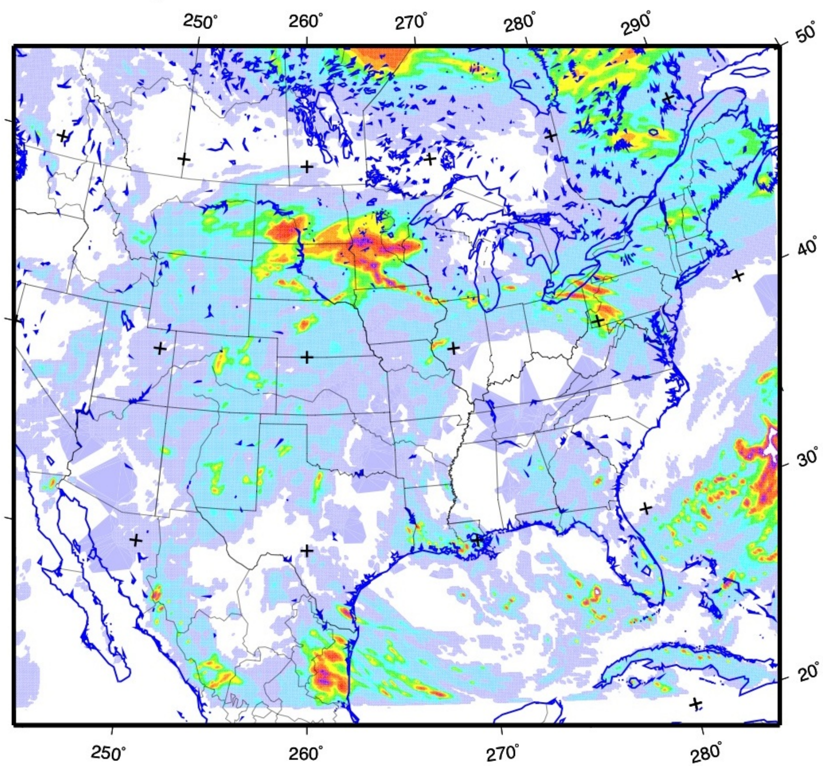


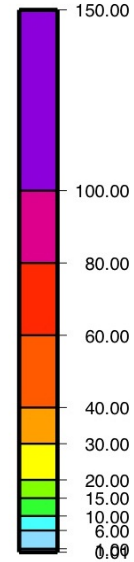
OBS

No parameterization

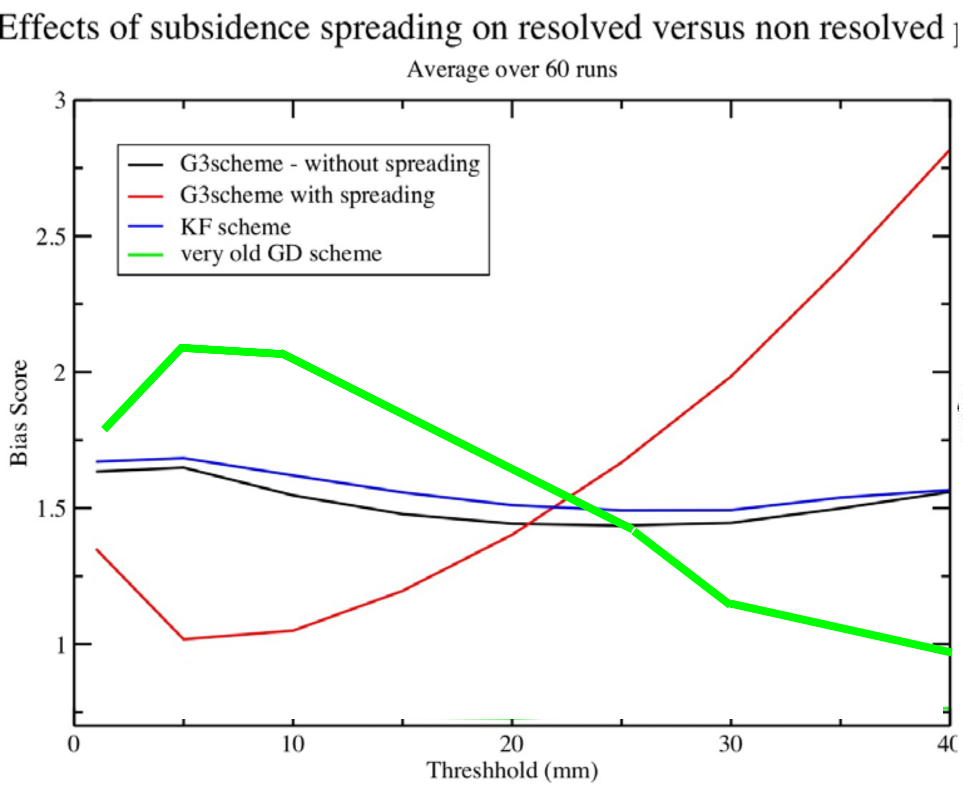


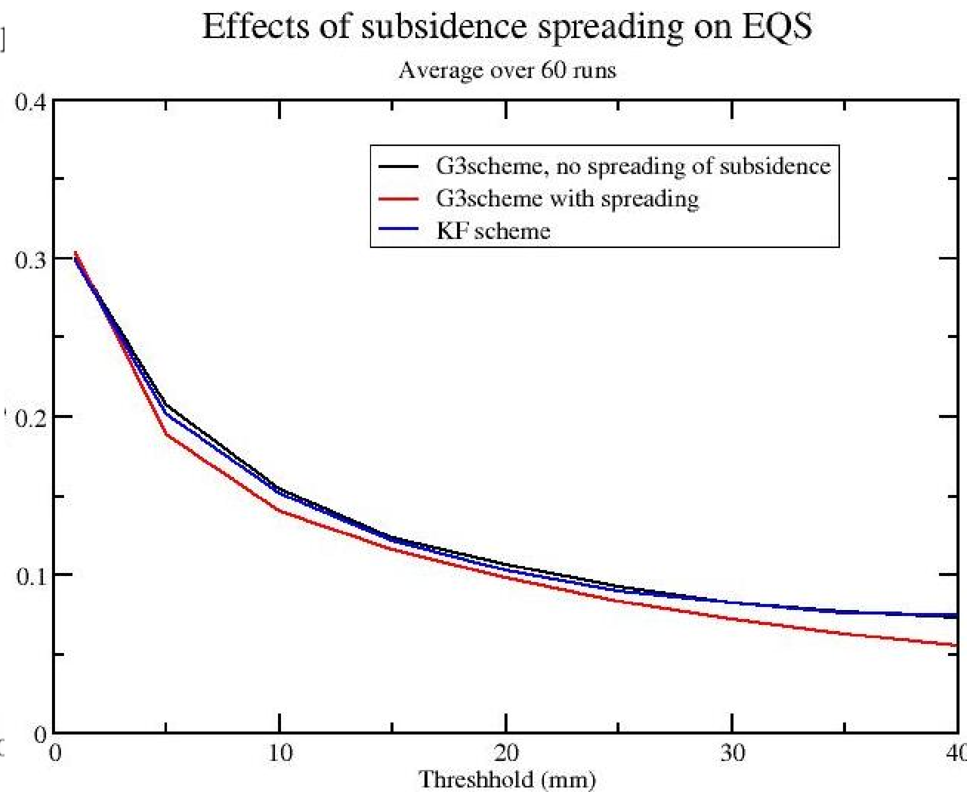
G3, with spreading





Bias and ETS scores over all runs!





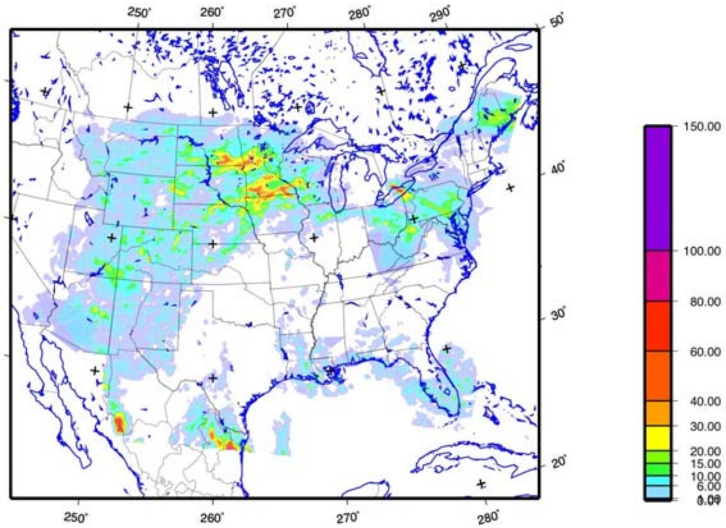
Summary and conclusions:

- The GD scheme is improved, ensembles are changed. Bias- and EQS-scores are improved.
- A 3-d version of the ensemble scheme is developed that spreads the subsidence effects over more than one grid cell
  - When spreading is turned on, the fraction of resolved precipitation increases drastically, especially for large thresholds
- Future and ongoing work:
  - Implement a smooth transition dependent on grid scale
  - Extend the range of spreading
  - Look at high resolution (dx=4km) case of mesoscale convective system (communication with Morris Weisman)
- Distant work: try the alternative approach of letting the resolved dynamics do all the subsidence

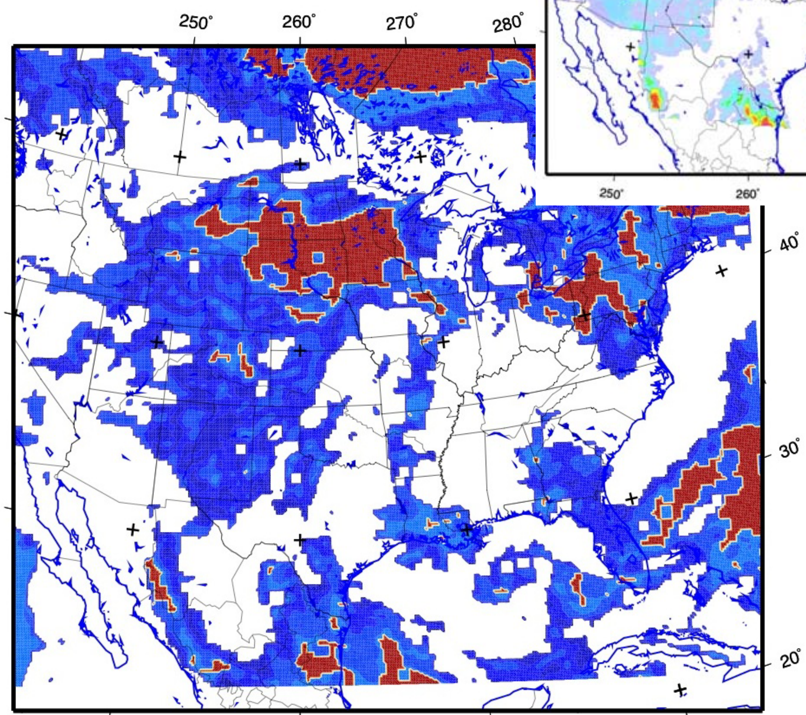
Sone examples of PDF and weight applications

- PDF’s are calculated on output (all ensemble precip rates), GD or G3
- 3 examples of weights: Constant everywhere (w1), threshold dependent(w2), and threshold dependent only applied to output (w3, not during run)

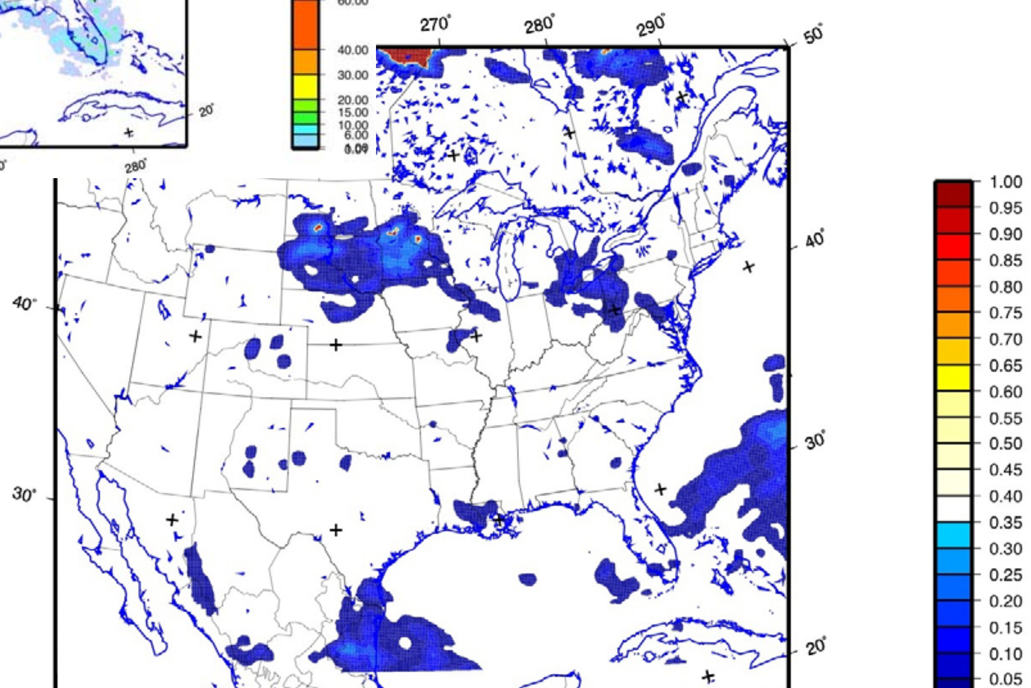
Probabilities for light and significant precipitation, 26-July 2005



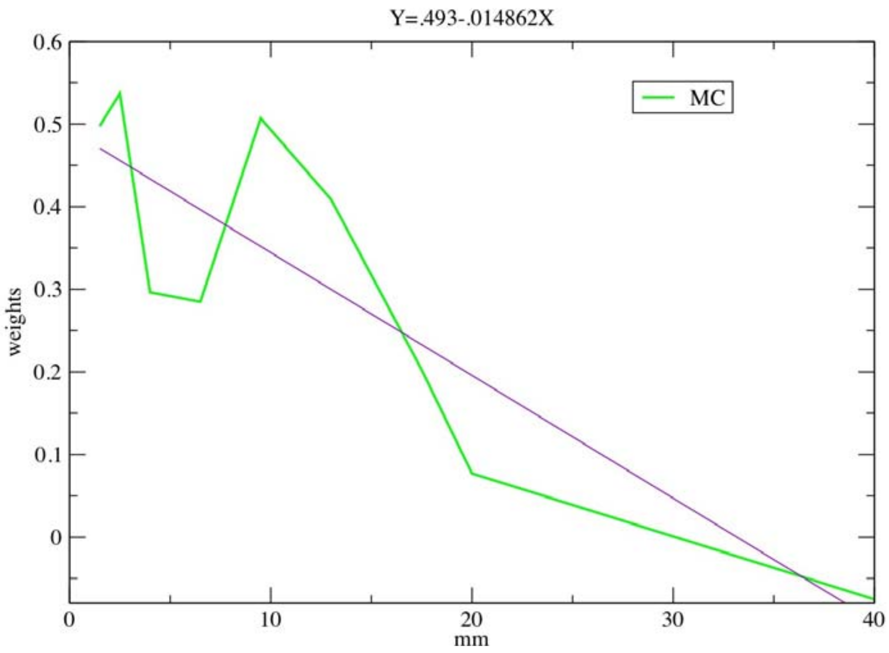
Light

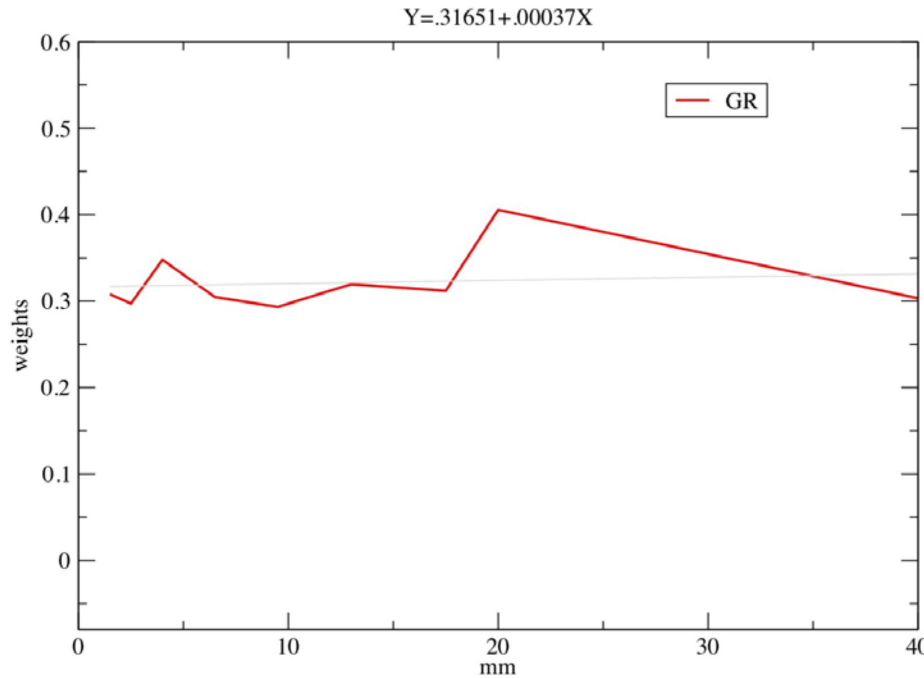


Significant



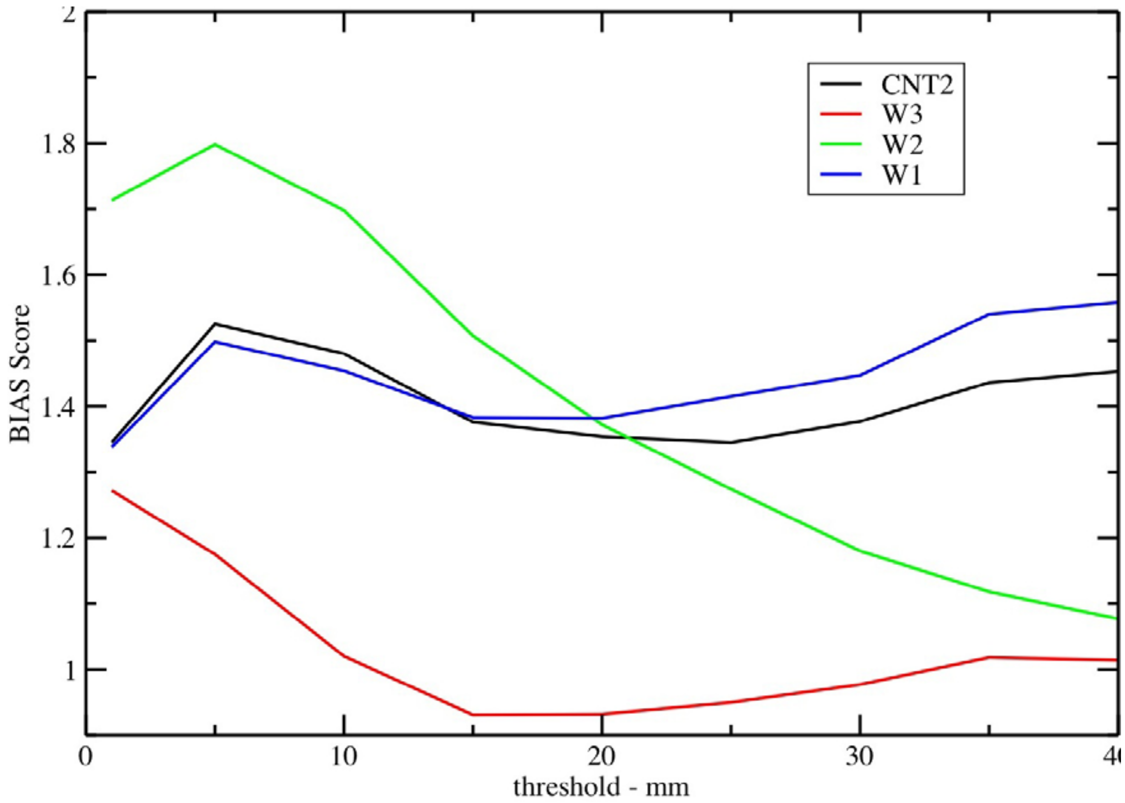
Threshold dependent weight calculation for 2 closures





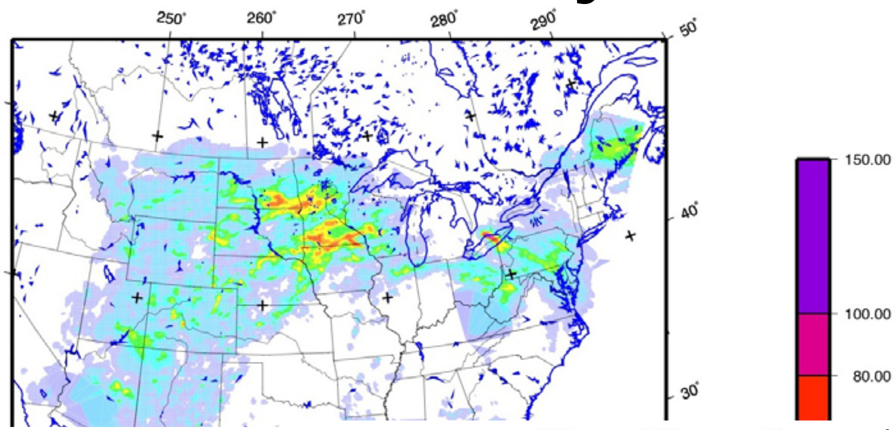
30 runs – WRF (first two weeks)

Different Weight calculations and their verification scores

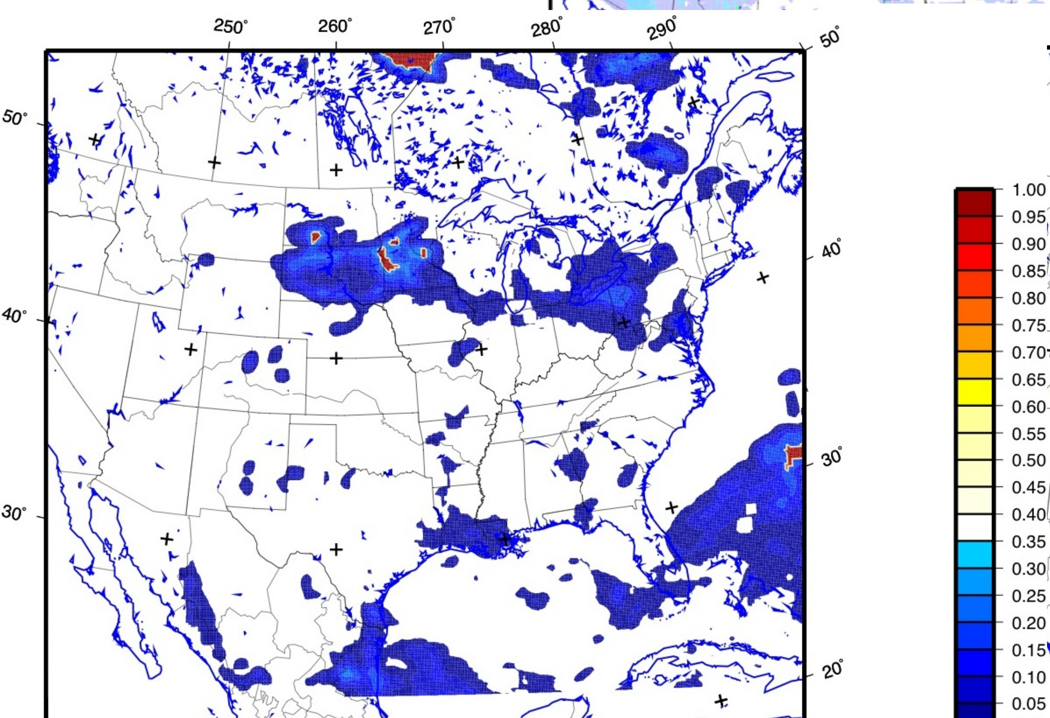


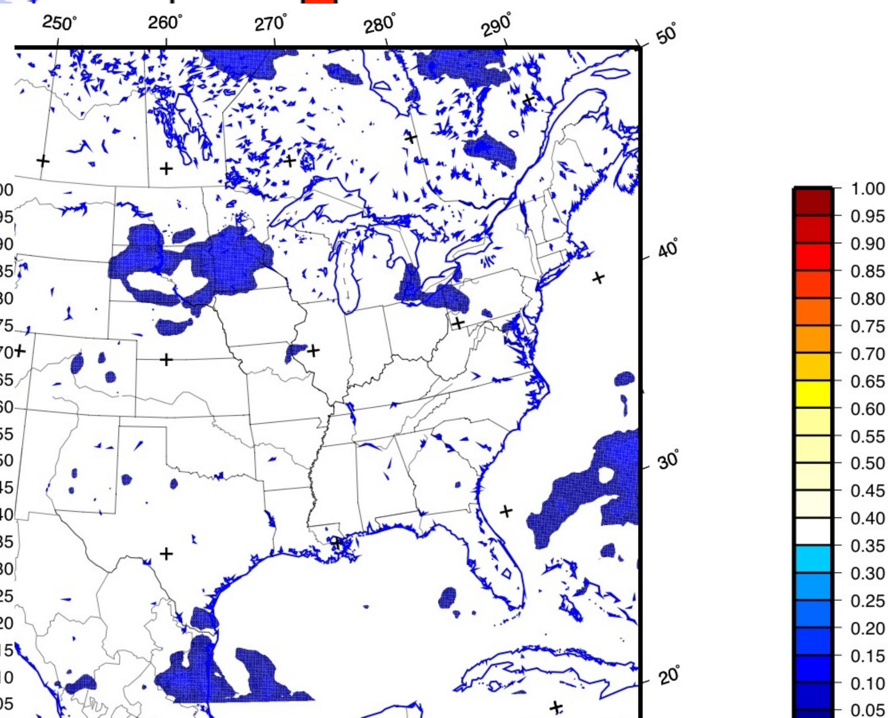
Bias Scores (last two weeks)

Probabilities for significant precipitation, 26-July 2005, Case



W1





What is next with training

- More statistics, more data, more runs, correlations with anything?
- Try simplex algorithm – linear programming (is being played with in Brazil)
- Advanced statistics: spatial-temporal quantile analysis methods or Baysian learning methods (A proposal by Lhiang and others did not get funded)
- Other nonlinear statistical regression: Neural network techniques