Modelling high precipitation intensity in orographic precipitation

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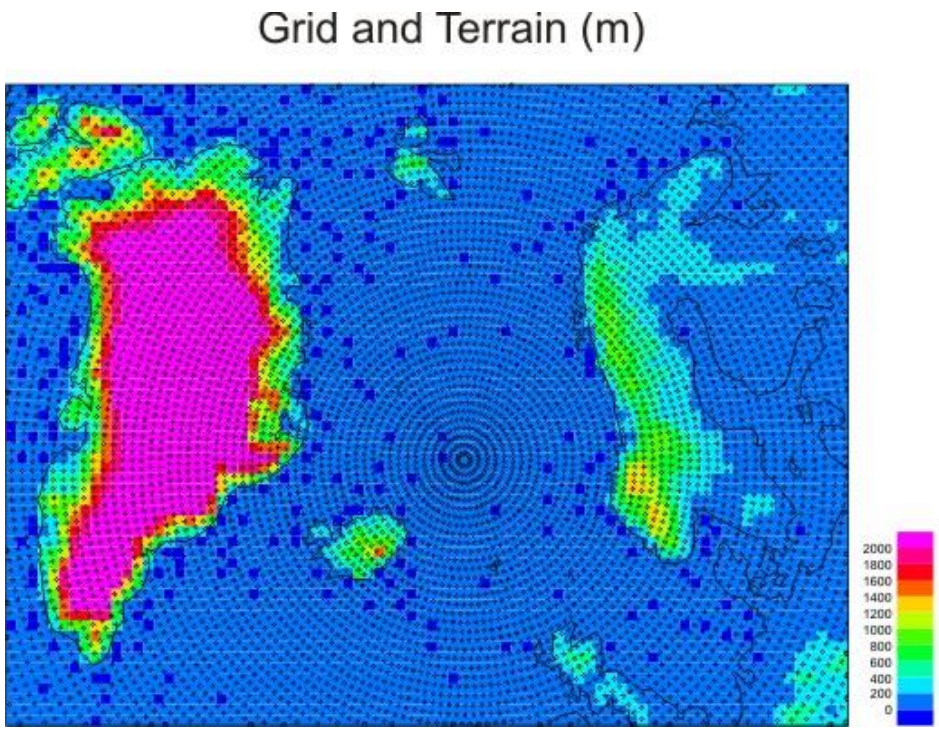
Guiding questions

- At what intensities do precipitation form?
- Are we able to model these intensities?
- Can we say something about the mechanism behind?

Grid and terrain for a downscaling simulation



ARPEGE-Ifs stretched

- *Time slice: 1960-2001*
- *Horizontal grid spacing: 25 km*
- *Nudge version (global) (correct lg.-sc. circulation)*
- *forced by ERA40 SST*

Barstad et al. (2008; Clim.Dyn.)

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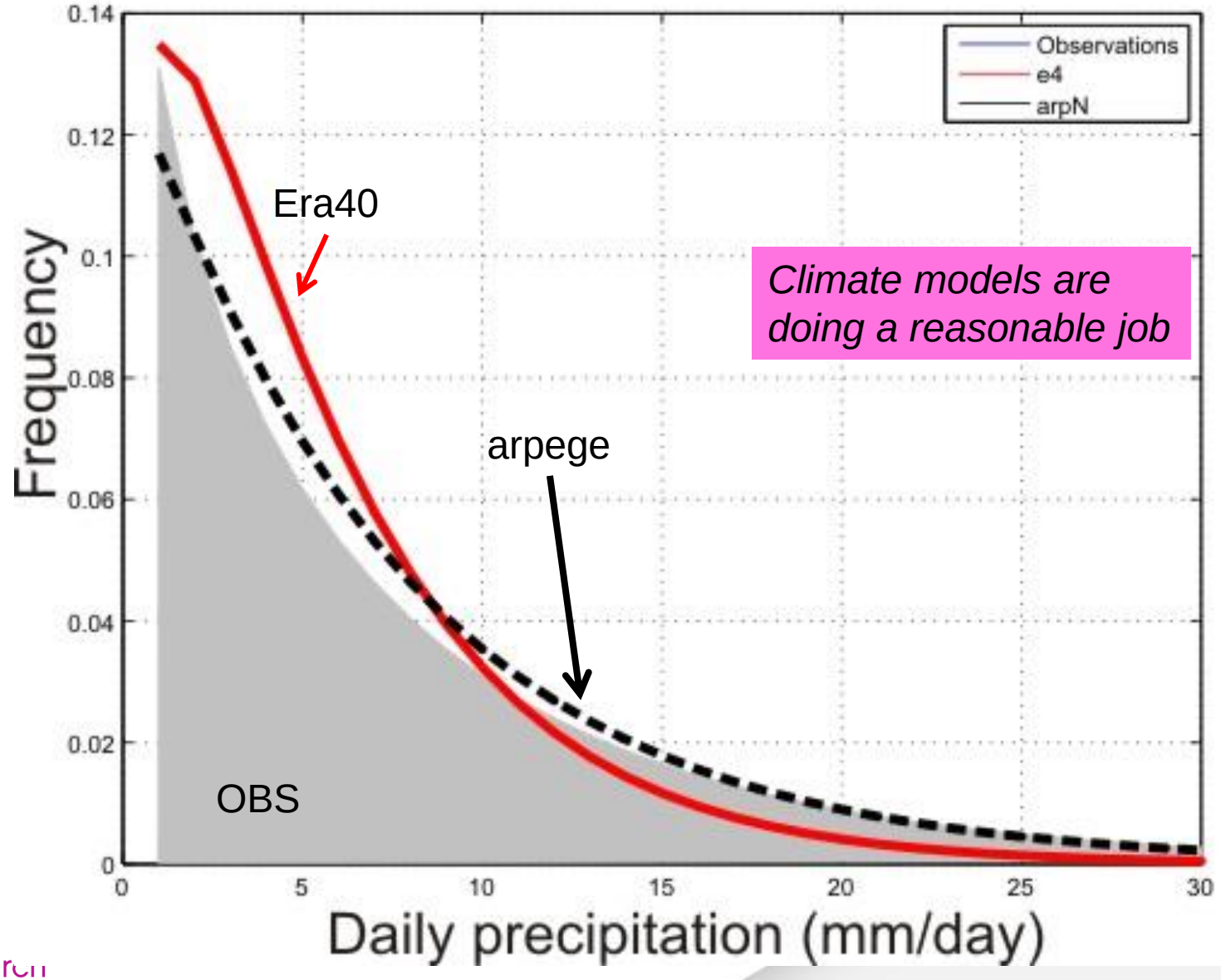
Norwegian precipitation stations (357):



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Storm tracks in global climate models

IPCC & CMIP5

Zappa et al. (2013a)

observed

bias

=> Models are too zonal (w-e directed)

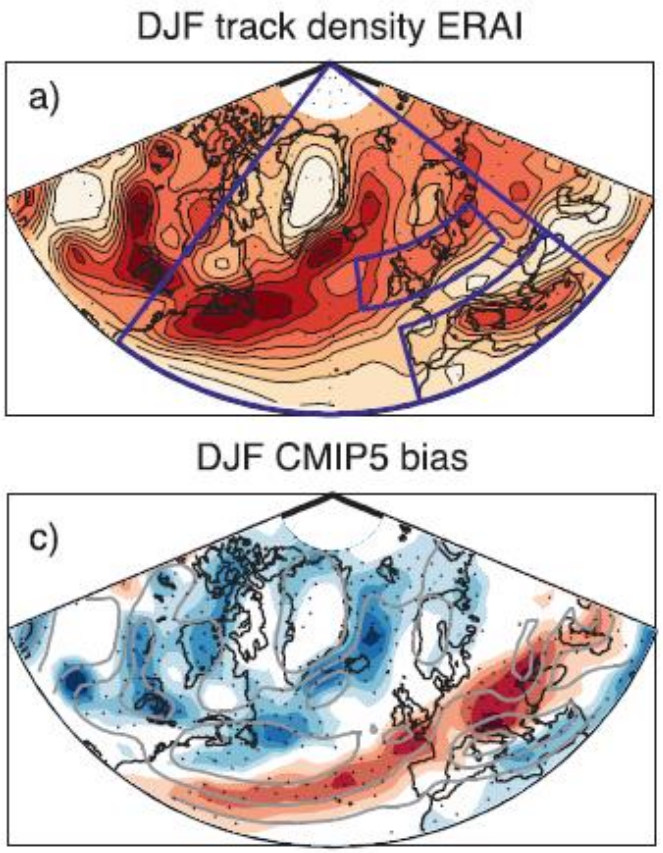

FIG. 1. (a),(b) Track density in ERA-Interim (1980–2009) and (c),(d) mean track density bias of CMIP5 models in the HIST simulations relative to ERA-Interim, for (left) DJF and (right) JJA. Units are in number of cyclones per month per unit area, where unit area is equivalent to a 5° spherical cap. In (a),(b), the large blue circular sector defines the region of the North Atlantic and European cyclones. The small boxes define the Mediterranean [in (a) only] and central European area of interests. In (c),(d), stippling shows where more than 80% of the models have a bias of the same sign, and the contours show the CMIP5-averaged track density with isolines every four cyclones per month per unit area.

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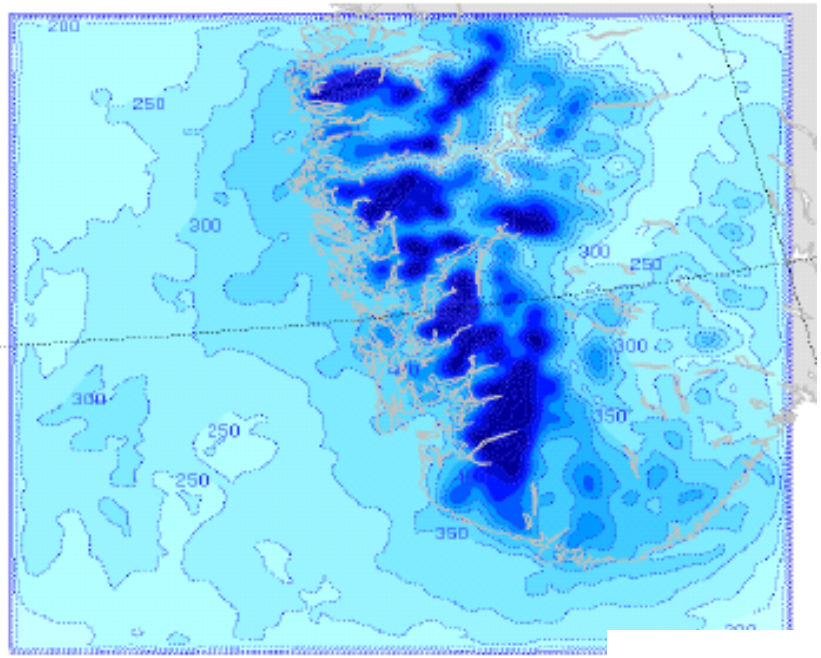
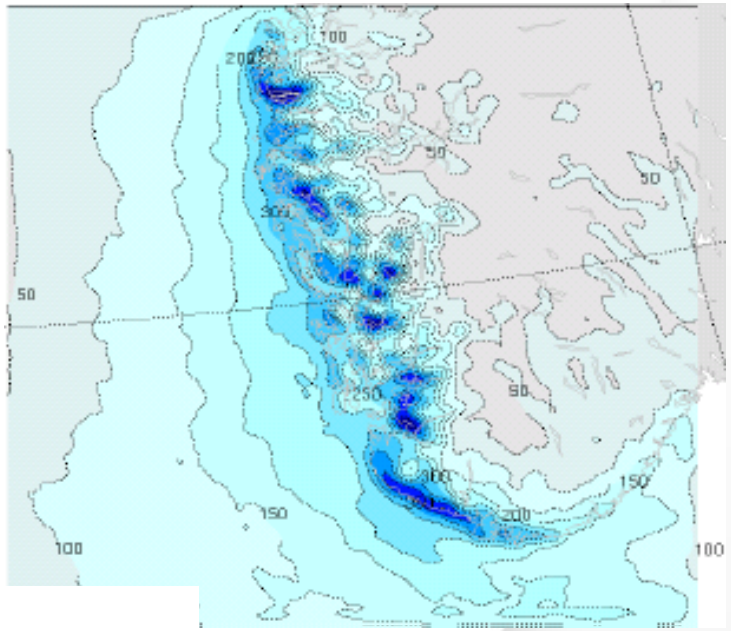
Total precipitation (12 weeks simulations)

3 km frontal

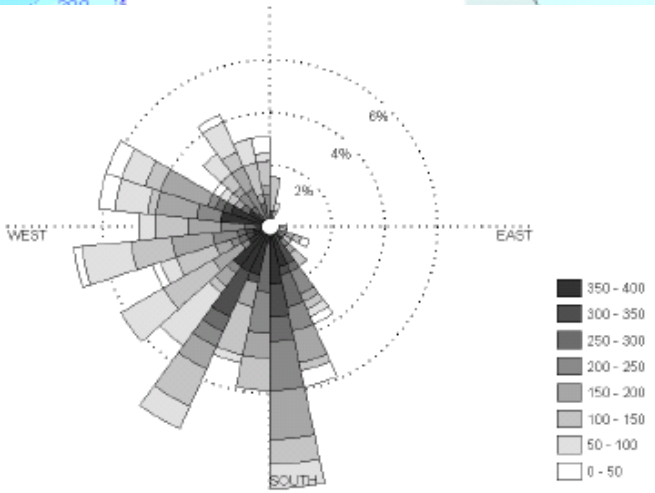


3 km convective



1/3 magnitude!

Vertically integrated water vapor rose



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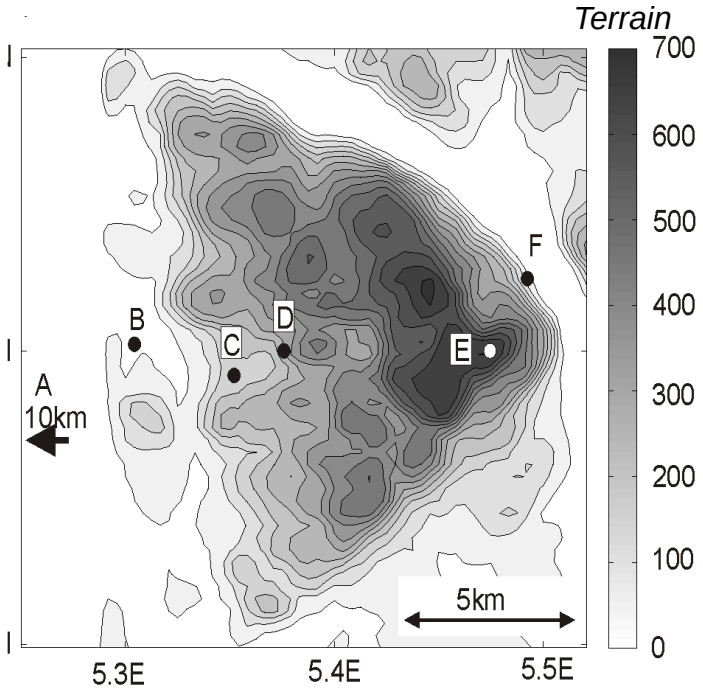
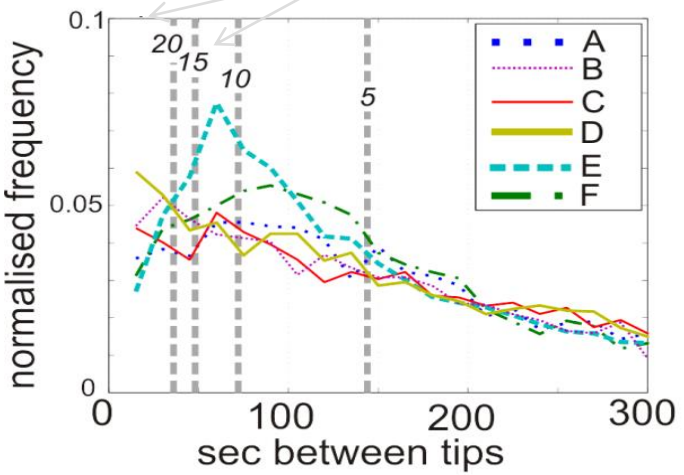
Rain – intensity (tipping buckets)

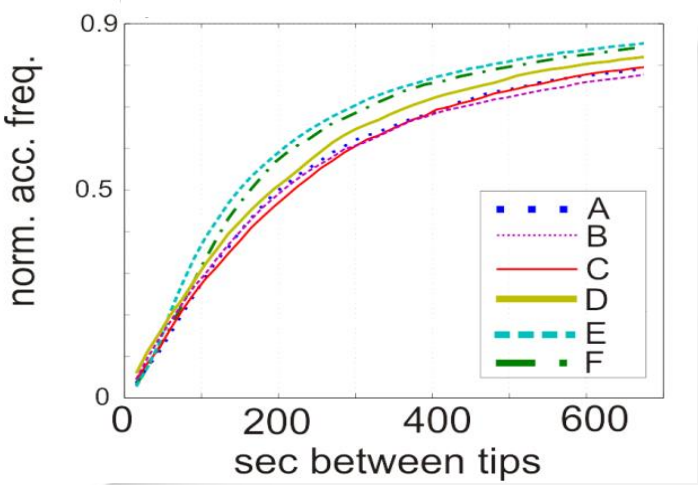
(Barstad and Caroletti 2012; QJRMS)



Precip-stations A-F
(Fall 2006)

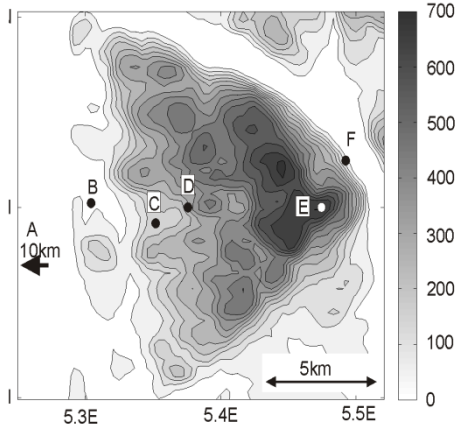
Intensity [mm/hr]





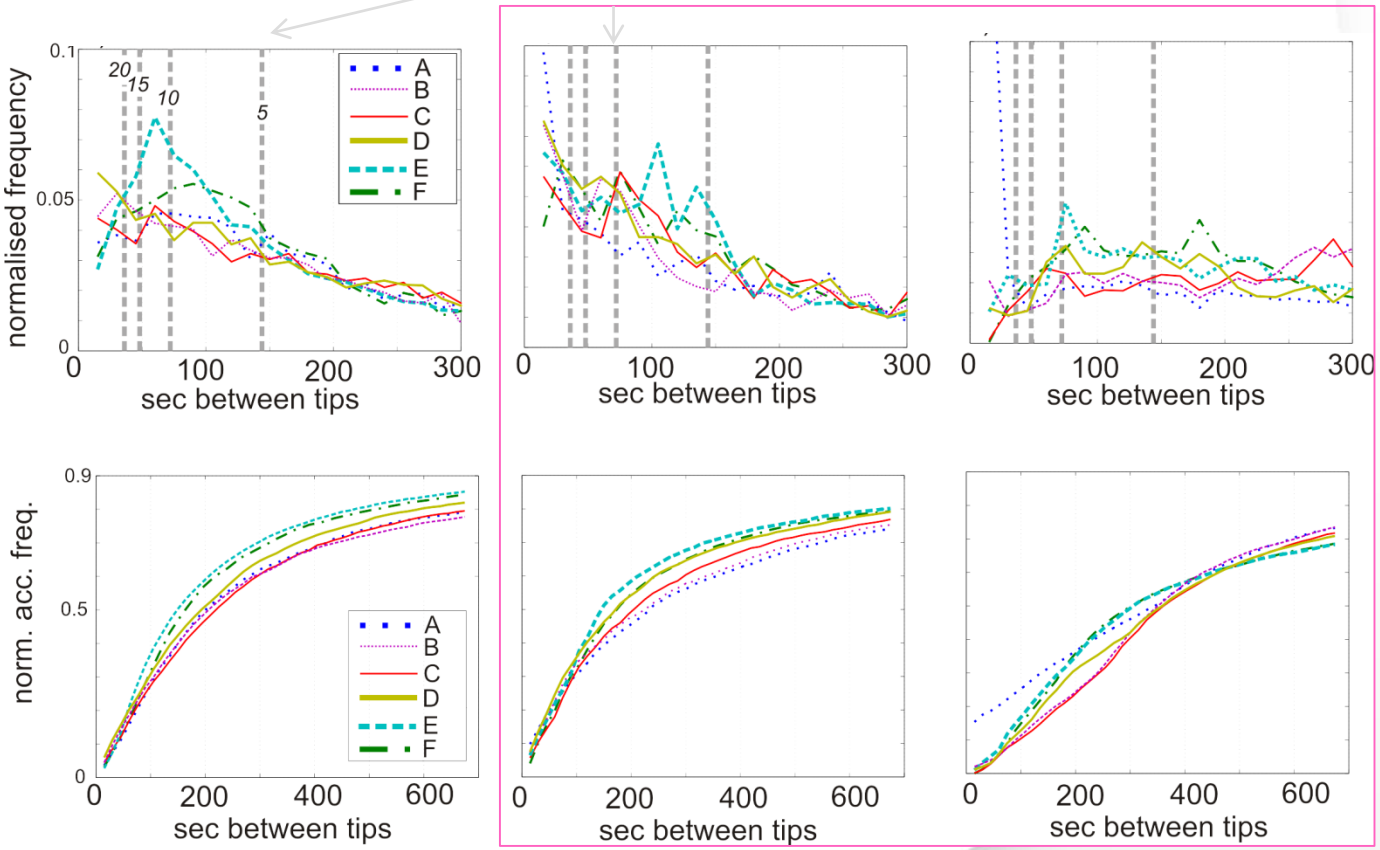
(0.2 mm in a tip)

Model comparison



Tipping buckets A-F

Intensity [mm/hr]

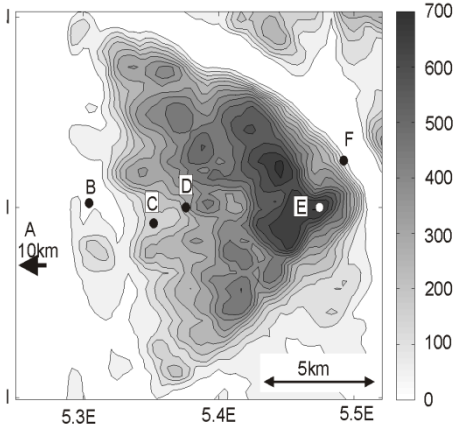


observations

1km grid

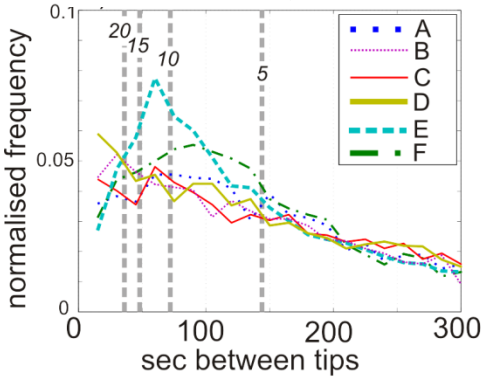
3km grid
conv. scheme

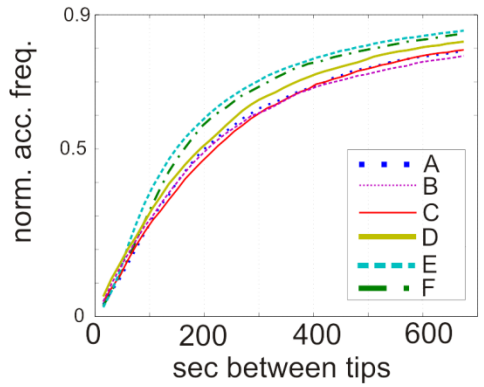
Model comparison

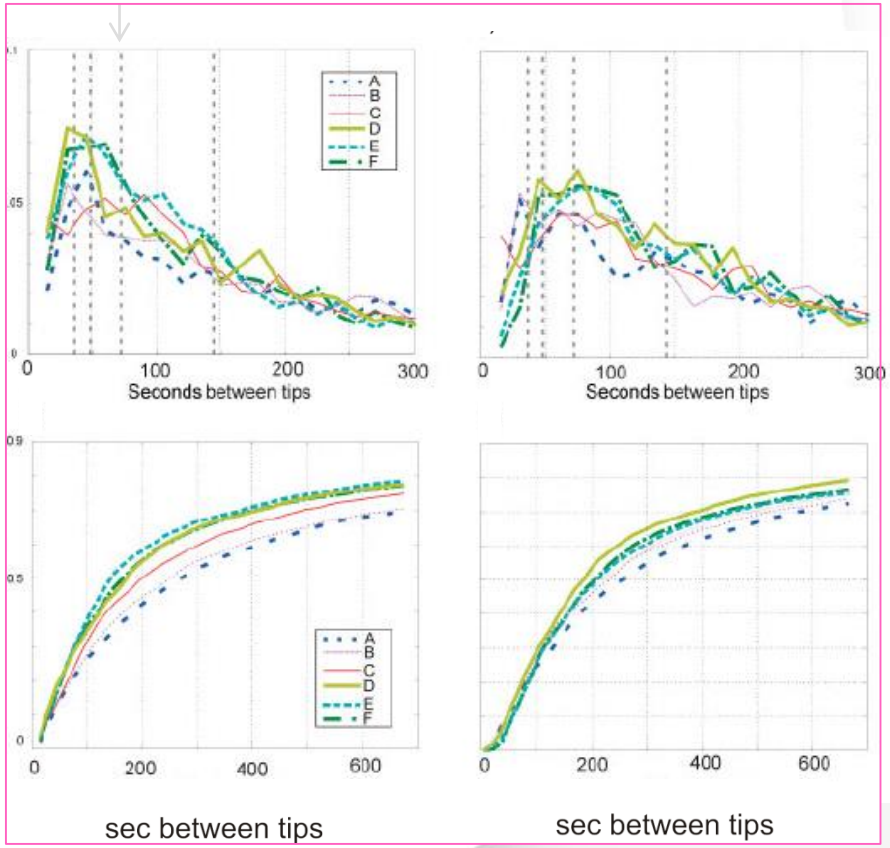


Tipping buckets A-F

Intensity [mm/hr]







observations

1km grid

3km grid

“Wind-ward lee-ward effect”

=> Over-enthusiastic convective scheme !

Two candidates:

- Horizontal water vapour flux
- Flux of buoyancy

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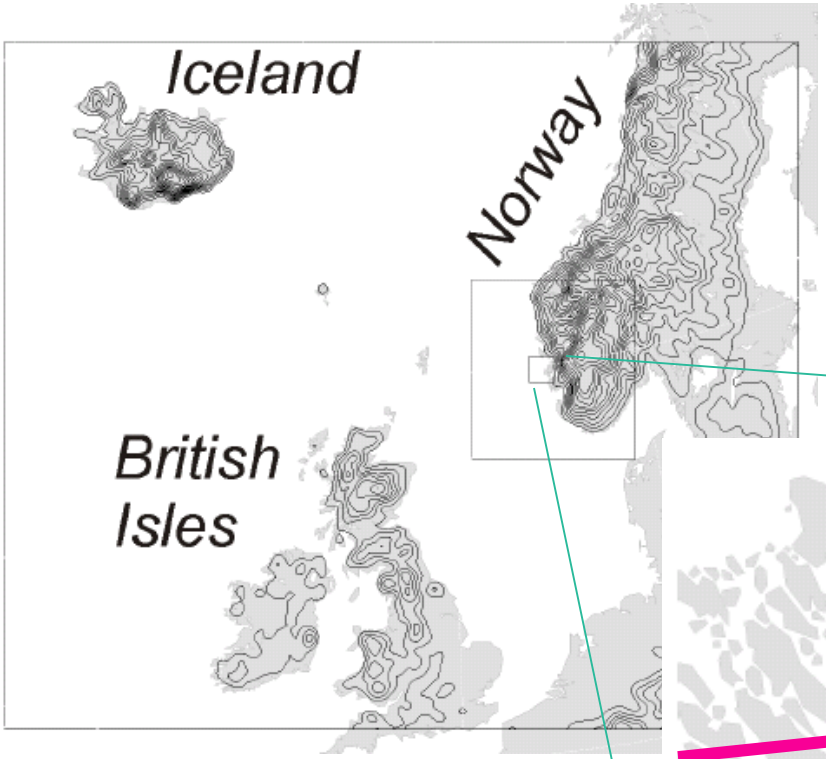
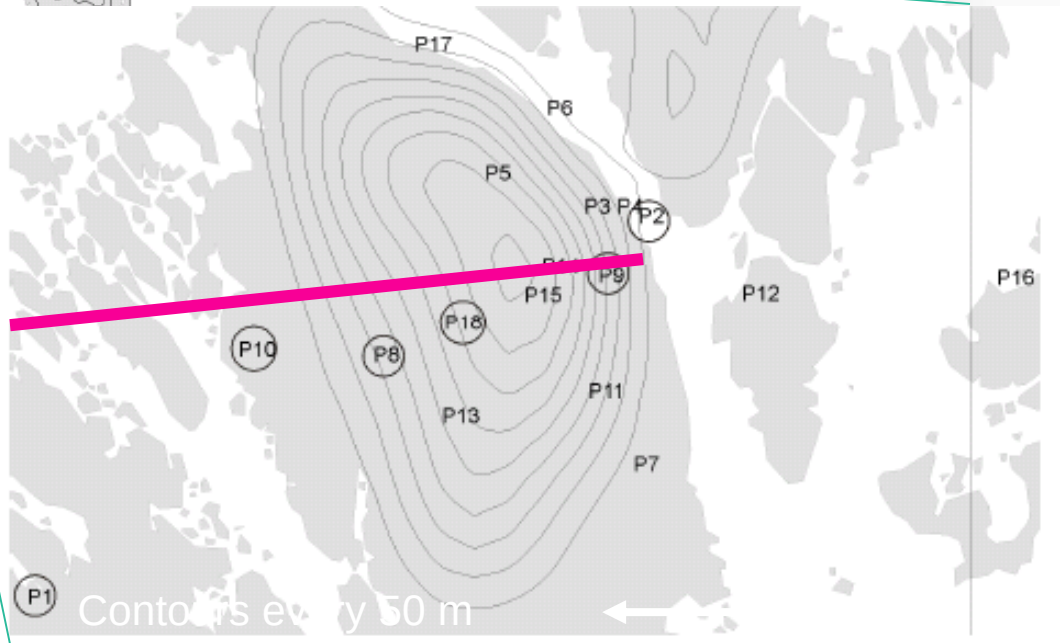
Numerical study with high resolution

9-3-1 km domain

26th Aug - 15th Nov 2006



~500 m peaks



Contours every 50 m

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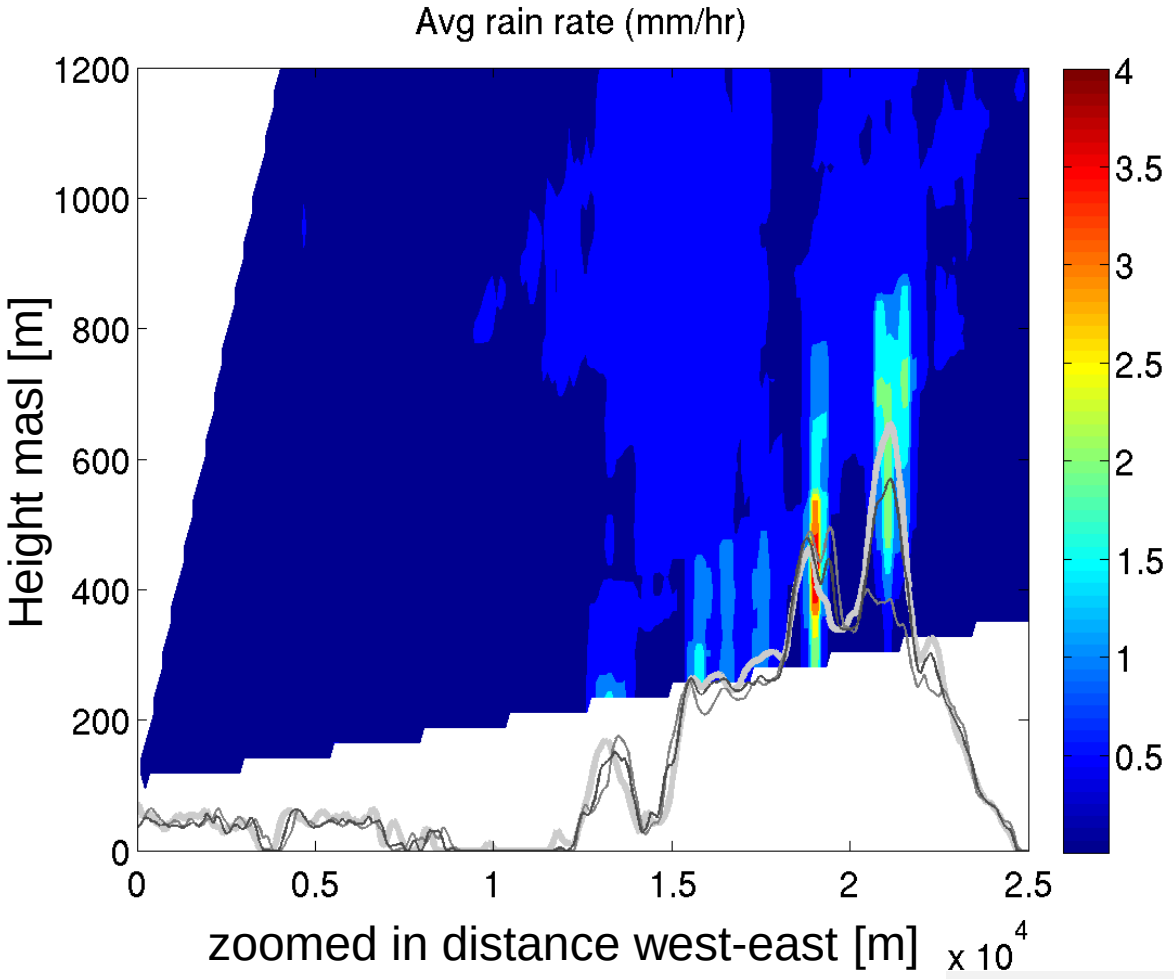
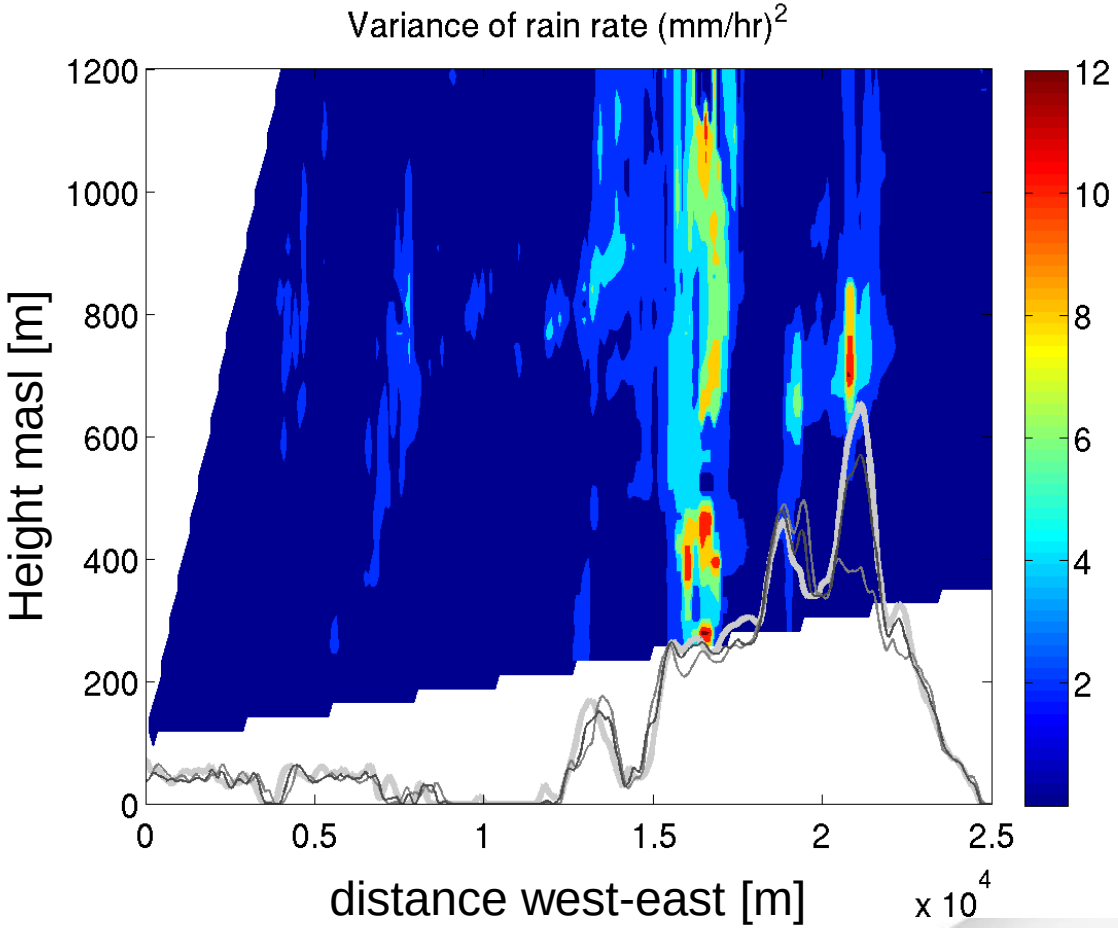
Radar cross-section west-east - avg rain rate



Radar cross-section west-east (variance of intensity)

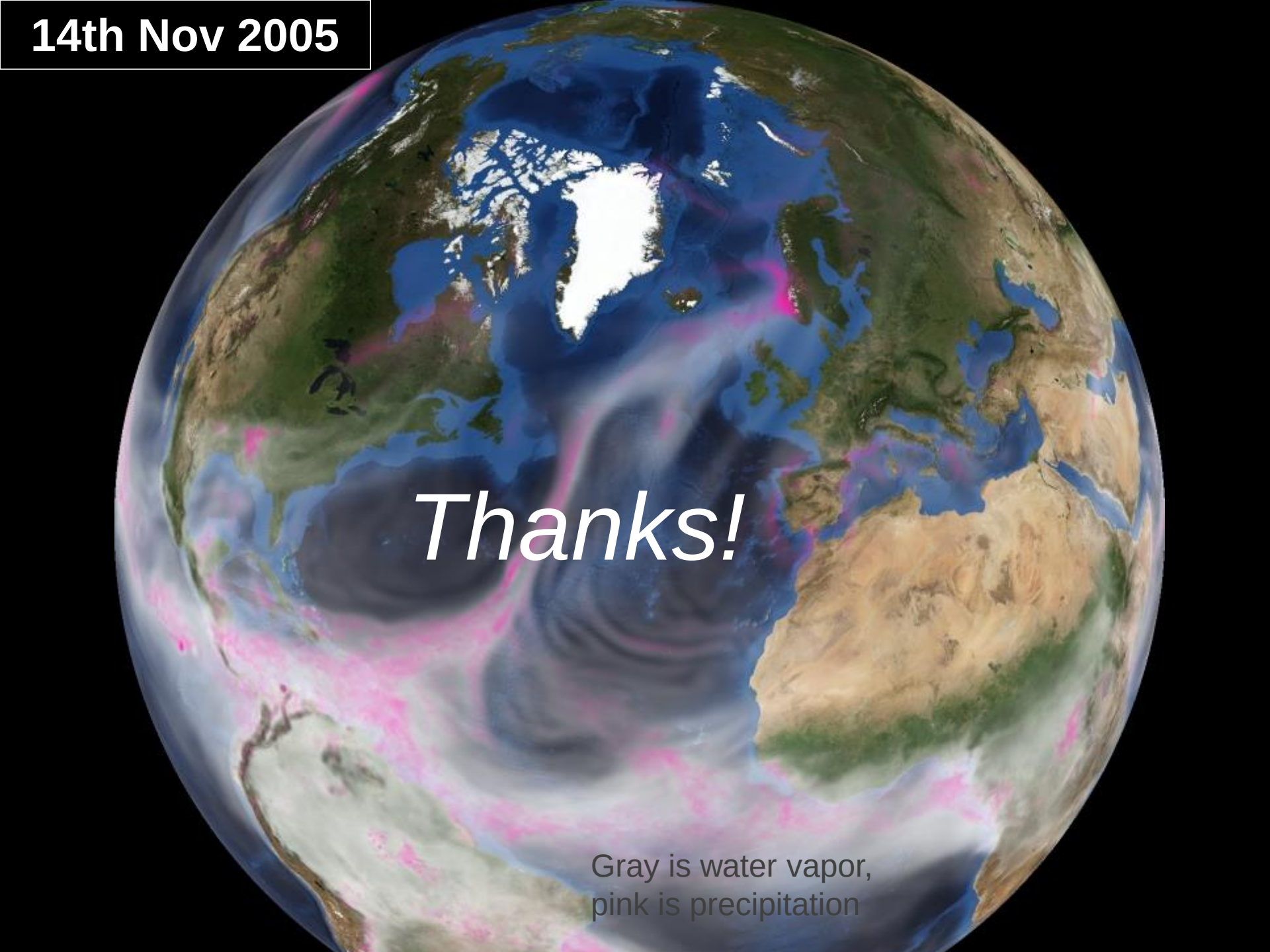


Another approach to the goal:

Reduced model efficient enough to downscaling across scenarios and across GCMs … but that is another story.

Summary

- The orographic precipitation is formed at intensities of, say, 10 mm/hr and upwards.
- Tipping buckets with 0.2 mm threshold makes it hard to work out the short time scales.
- Numerical models can resolve these with sufficient resolution and set-up design. Convective simulations are still questionable.
- Embedded convection is frequent, even beyond 60N
- See my poster and talk to Ethan Gutmann to learn more about capabilities of reduced models.


14th Nov 2005
Thanks!
Gray is water vapor,
pink is precipitation