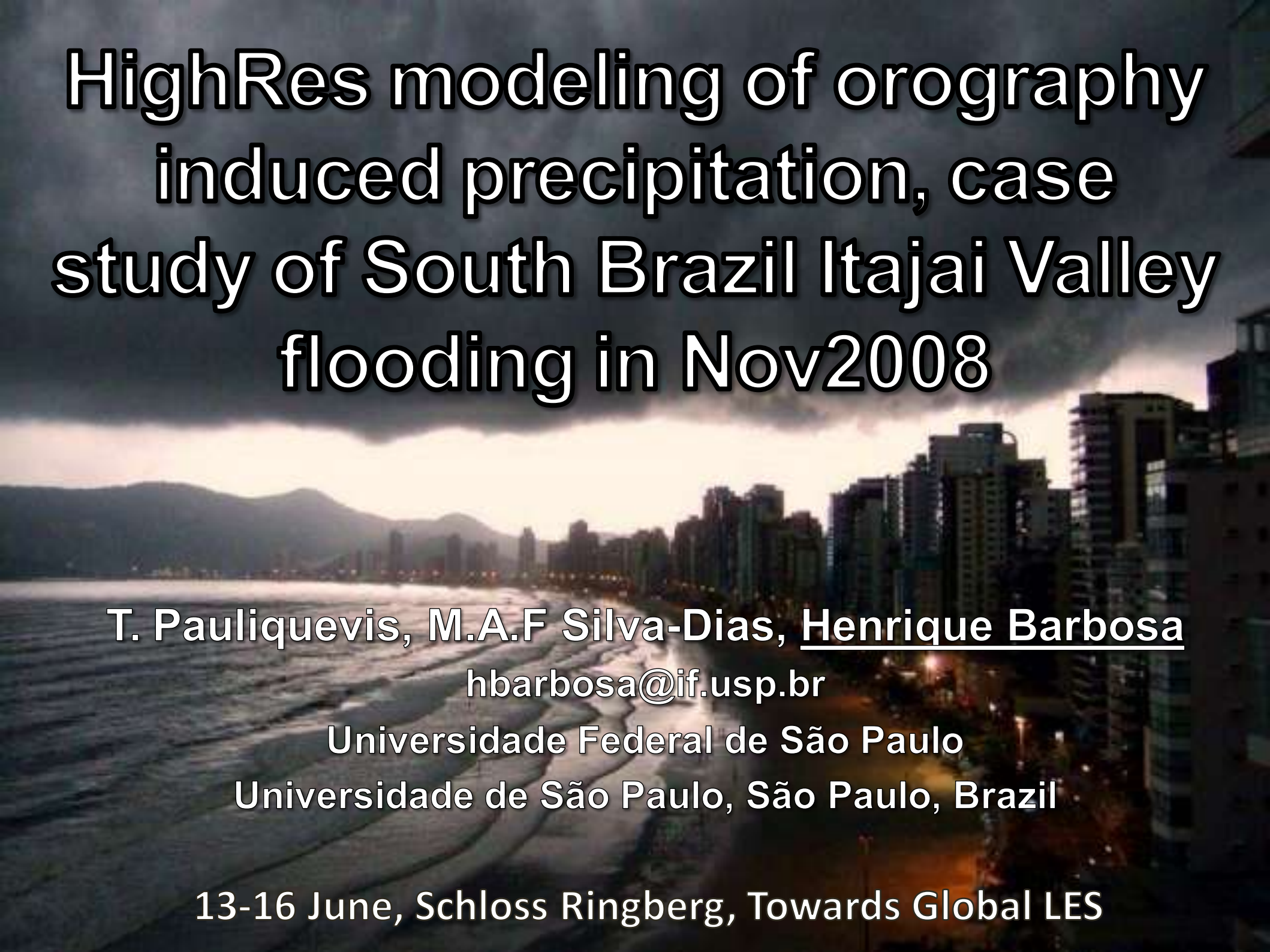
HighRes modeling of orography induced precipitation, case study of South Brazil Itajai Valley flooding in Nov2008



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Universidade de São Paulo, São Paulo, Brazil

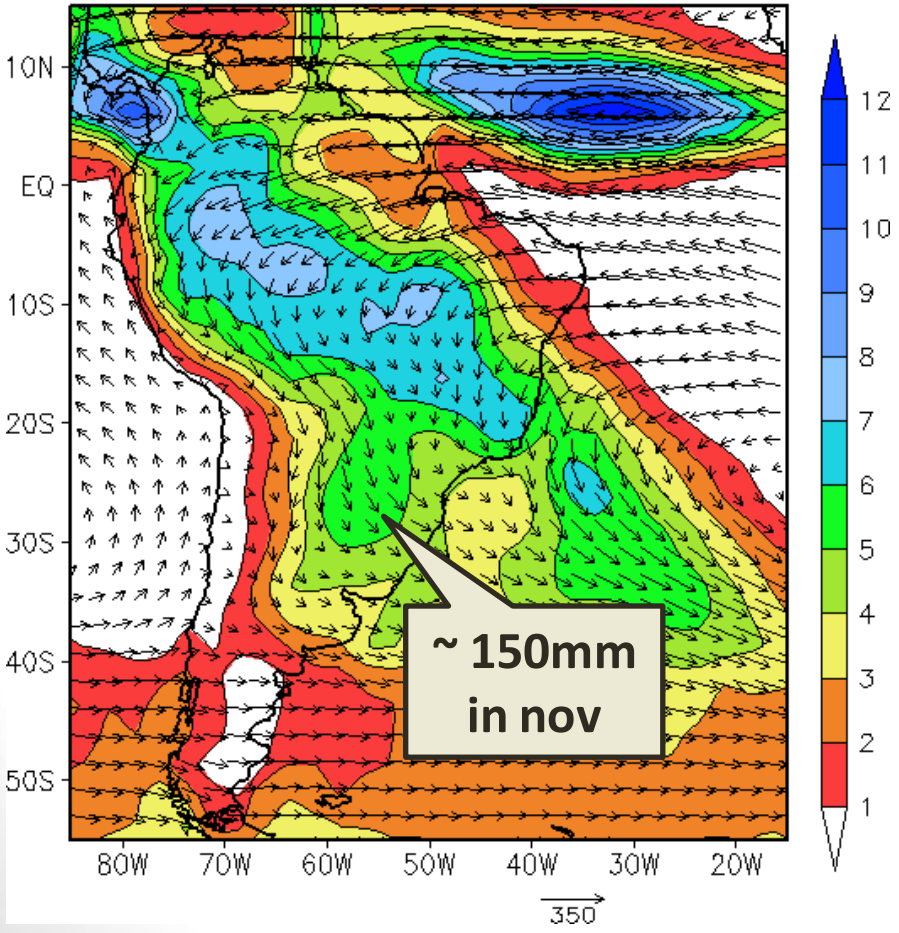
13-16 June, Schloss Ringberg, Towards Global LES

Event of extreme precipitation over complex terrain

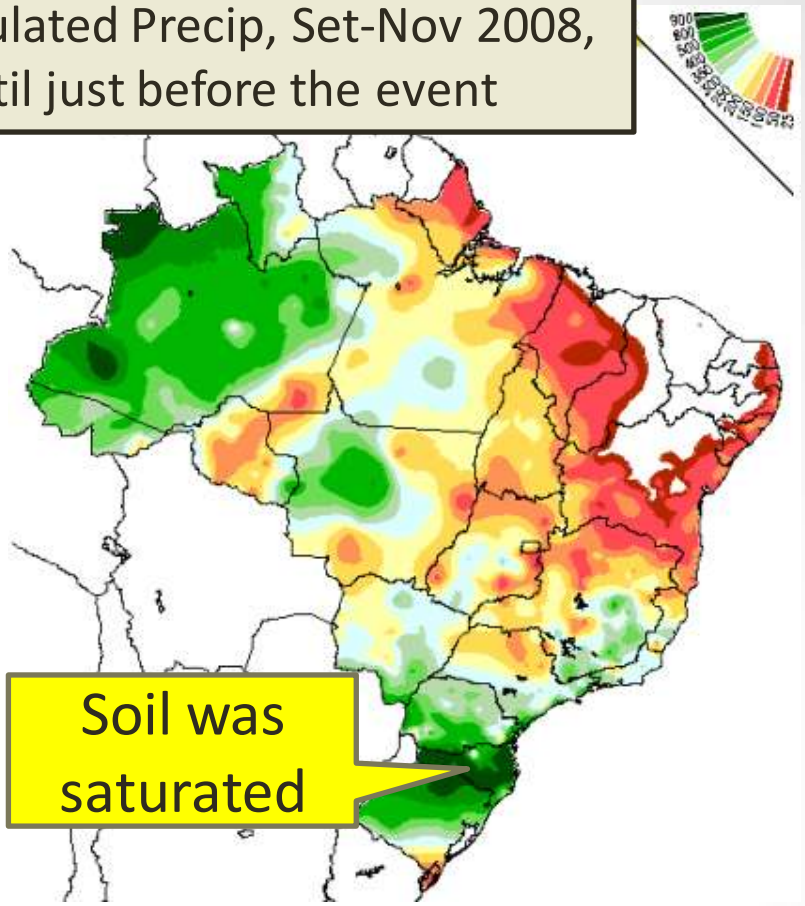
- South of Brazil, 20-24 November 2008
- Hourly precipitation classified as moderate
  - but it rained continuously for more than 4 days
  - **Accum. Precip 21-24/nov ~ 700mm!**
- Social impacts
  - 60 cities and 1.5 million people directly affected
  - 78k people left their home
  - 155 deaths

Climatology x Nov 2008

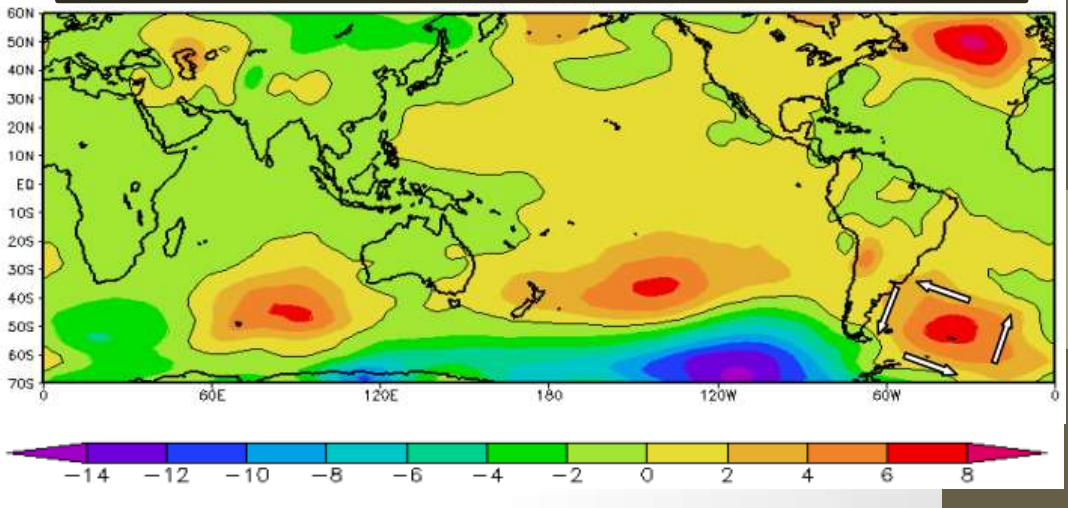
Moisture Trans. and Precip. – Nov
GPCP + ECMWF ERA40, 80-2001



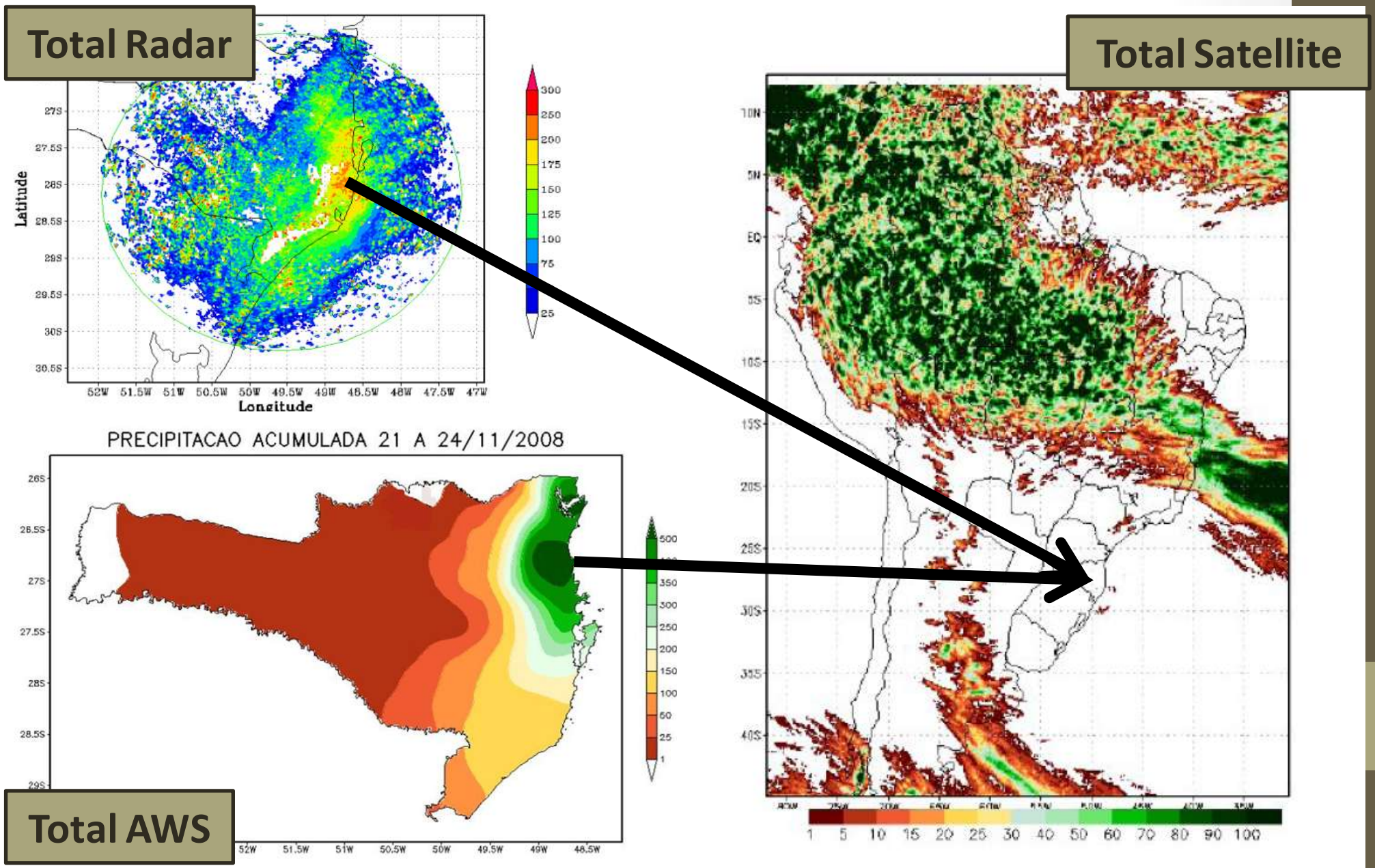
Accumulated Precip, Set-Nov 2008,
until just before the event



Sea Level Pressure Anomalies (SON-2008)

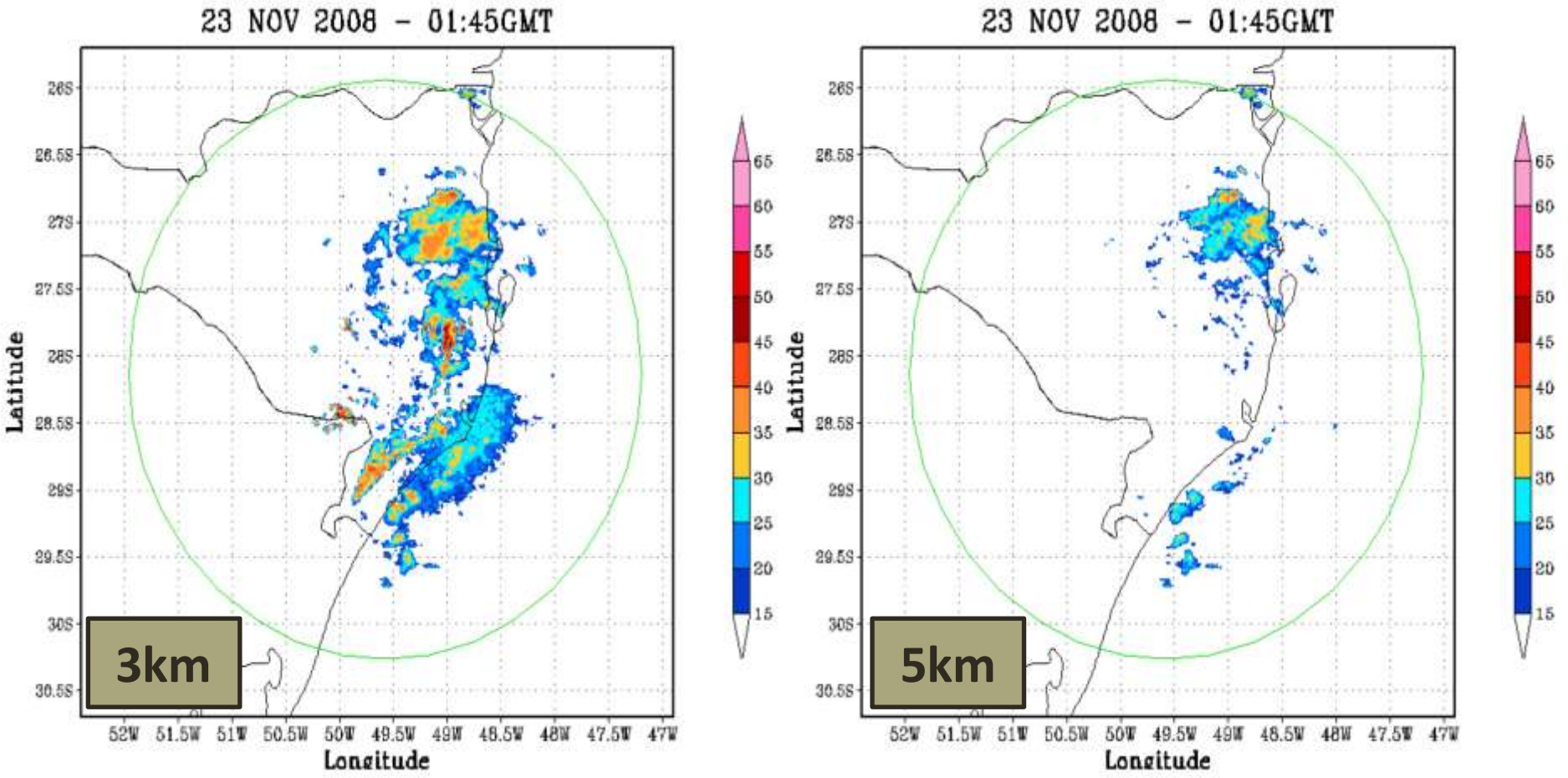


700mm between 21-24 Nov 08



Radar @ 1822m a.s.l.

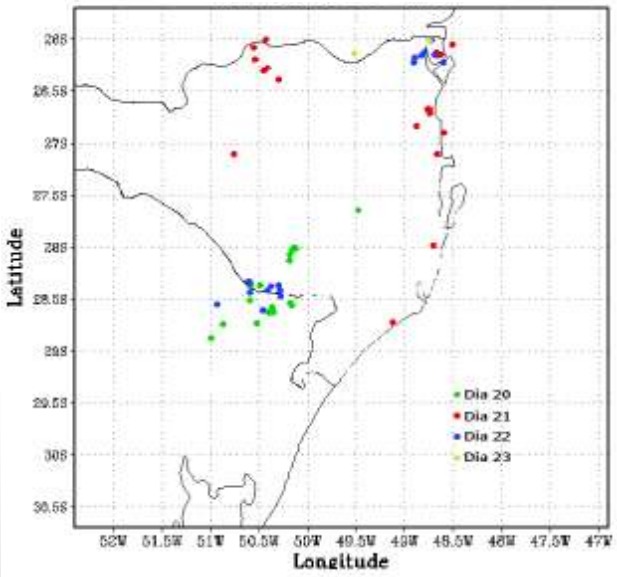
- Warm precipitation
- But total is underestimated



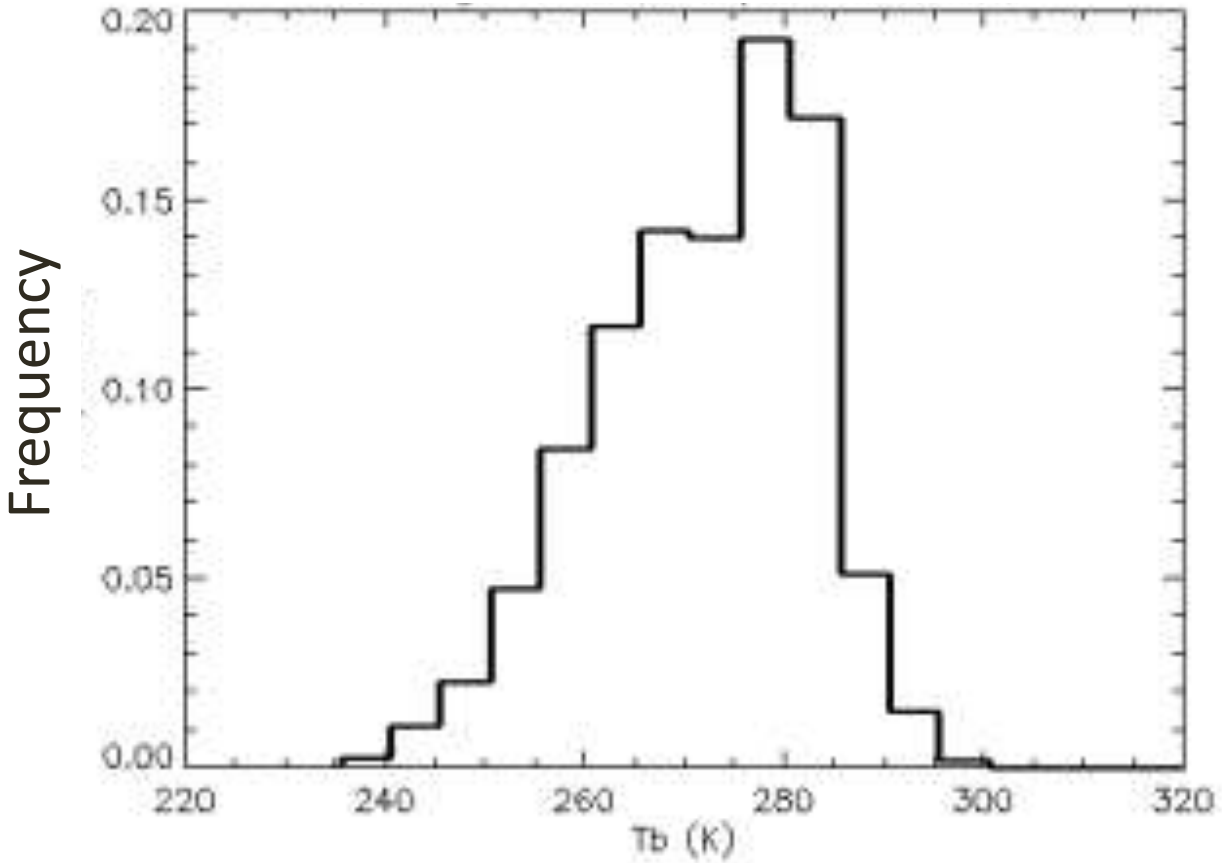
CTT GOES-10

- Distribution of cloud top temperature over Santa Catarina State shows a prevalence of warm clouds.
  - 97% warm clouds
  - 3% cold clouds

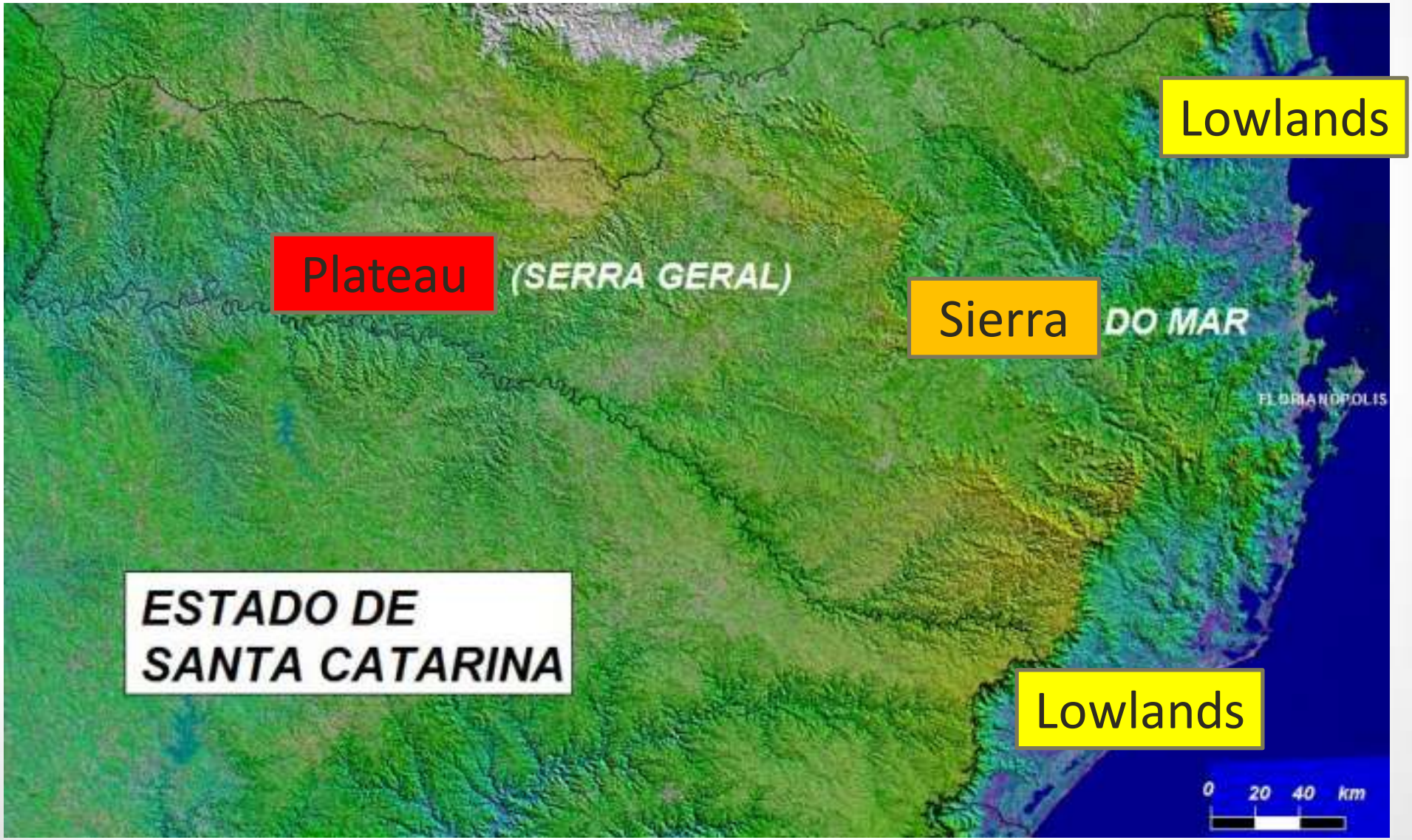
Lightning



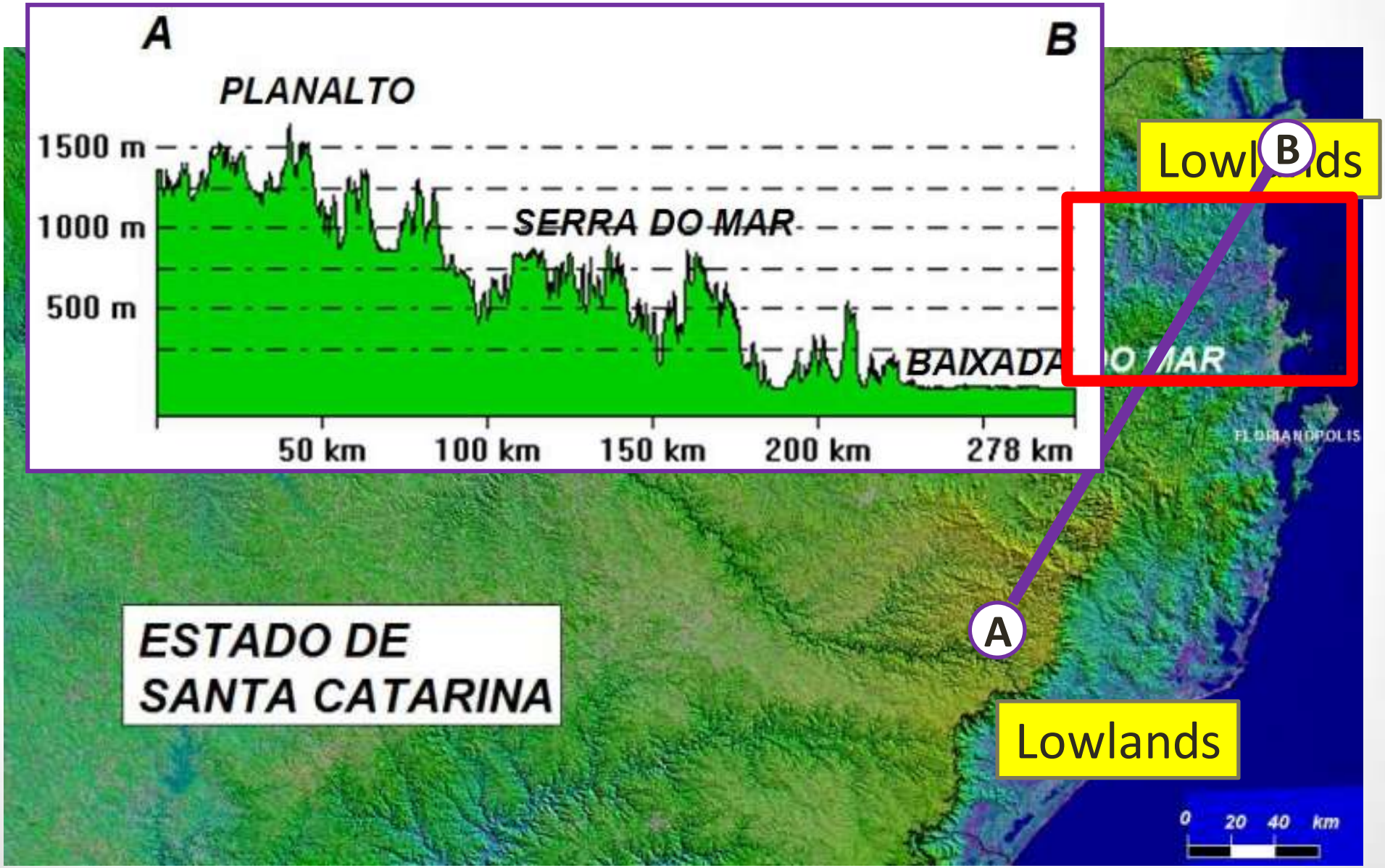
Brightness Temp. distribution



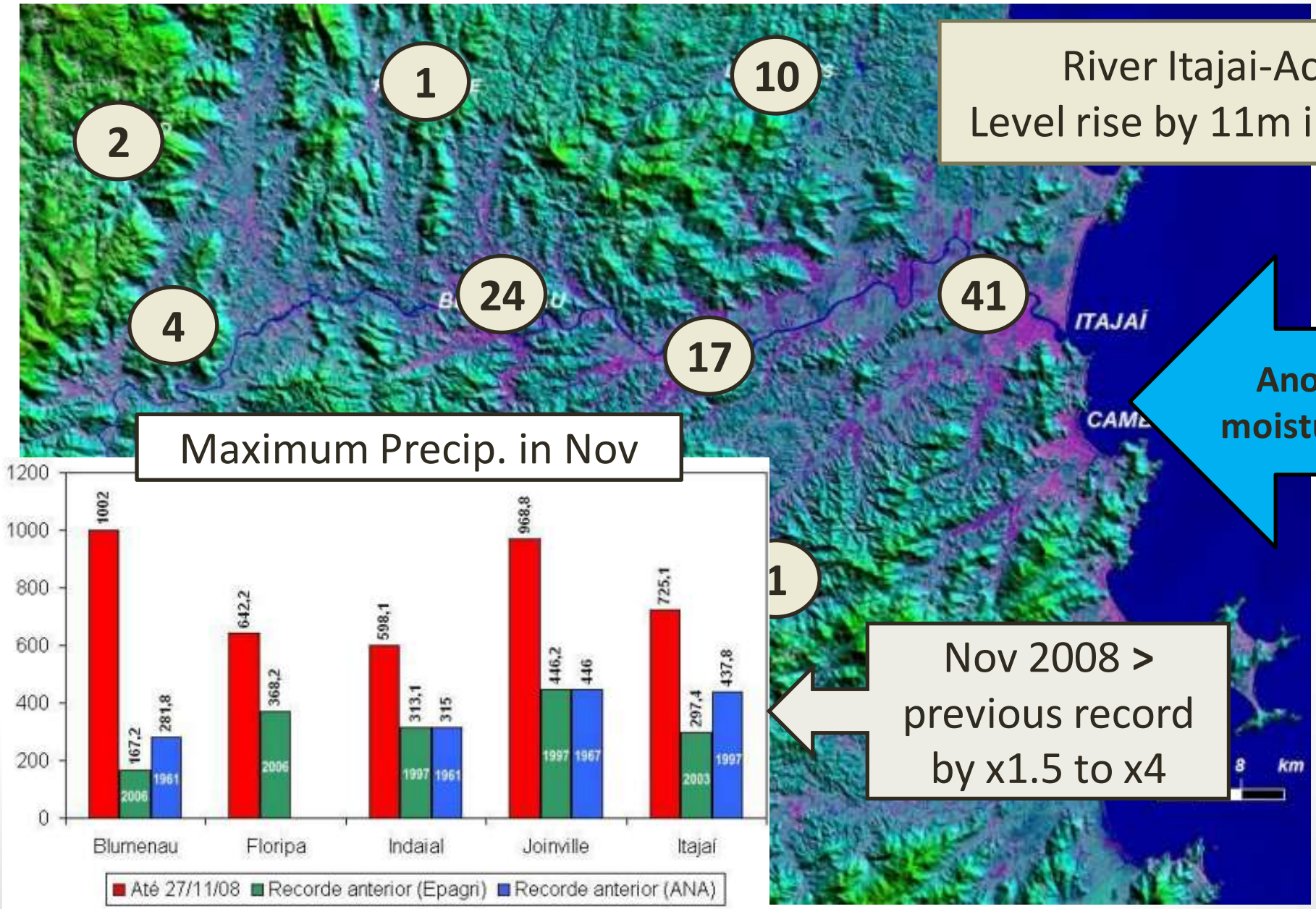
3 geomorphological compartments



3 geomorphological compartments



Complex Terrain – Itajaí Valley



Different Models

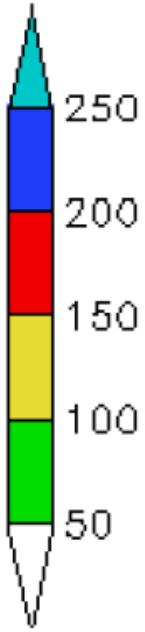
Different models were able to capture the event in different ways.

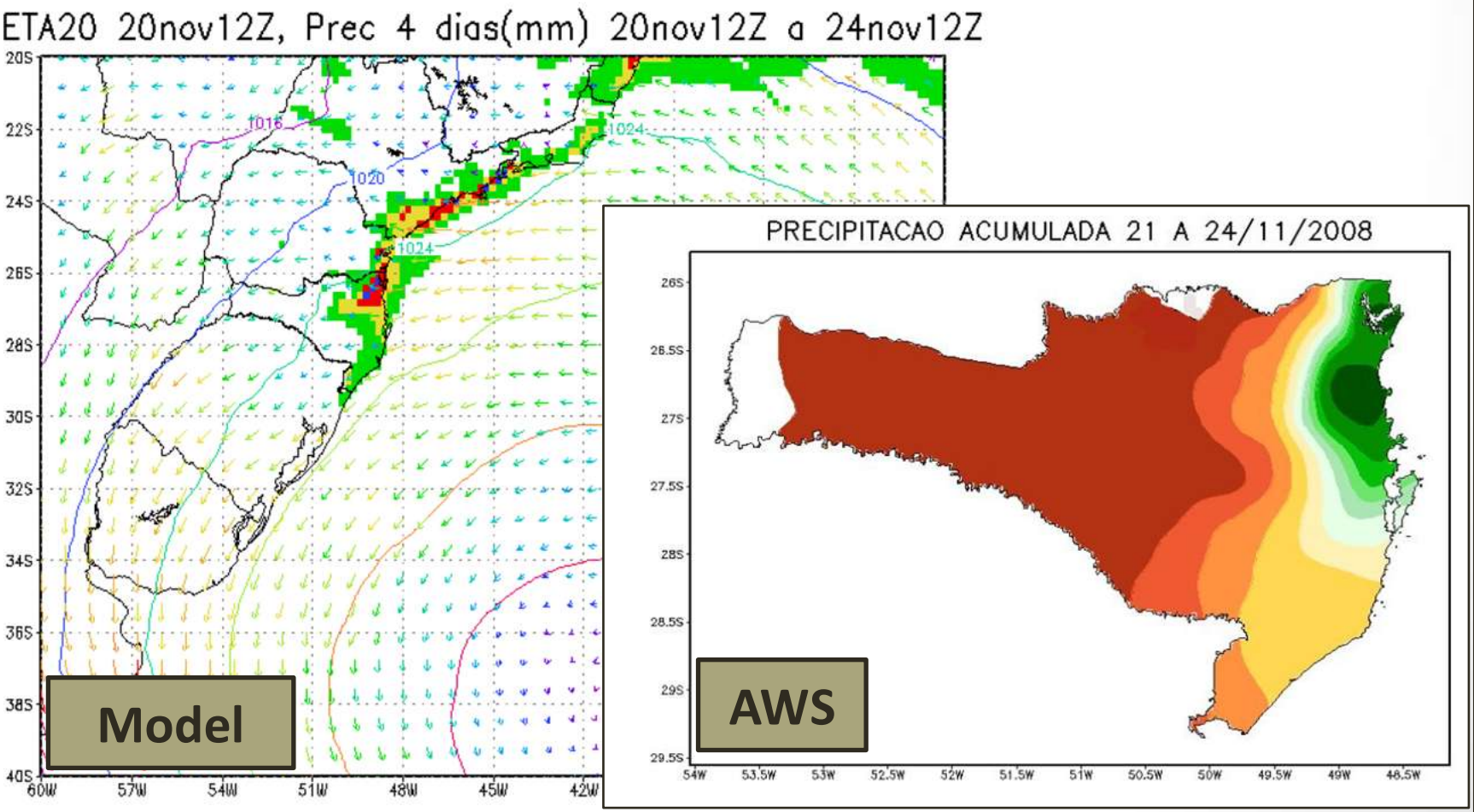
- CPTEC Global model forecasted the blocking 10 days in advance
- Global and regional models forecasted the movement of a cyclonic vortex in high levels towards Santa Catarina

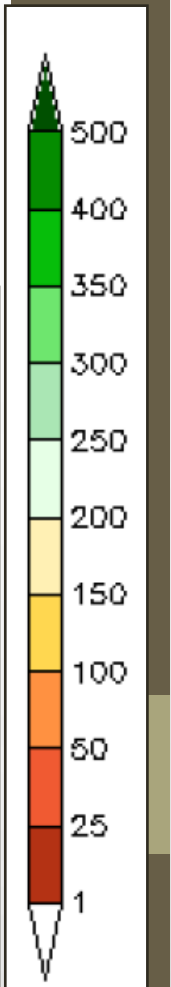
However, all models failed to even grasp the magnitude of the event

ETA Model, 20km - Operational

- Forecast indicated above normal precipitation, but total was **underestimated by a factor of 3.**

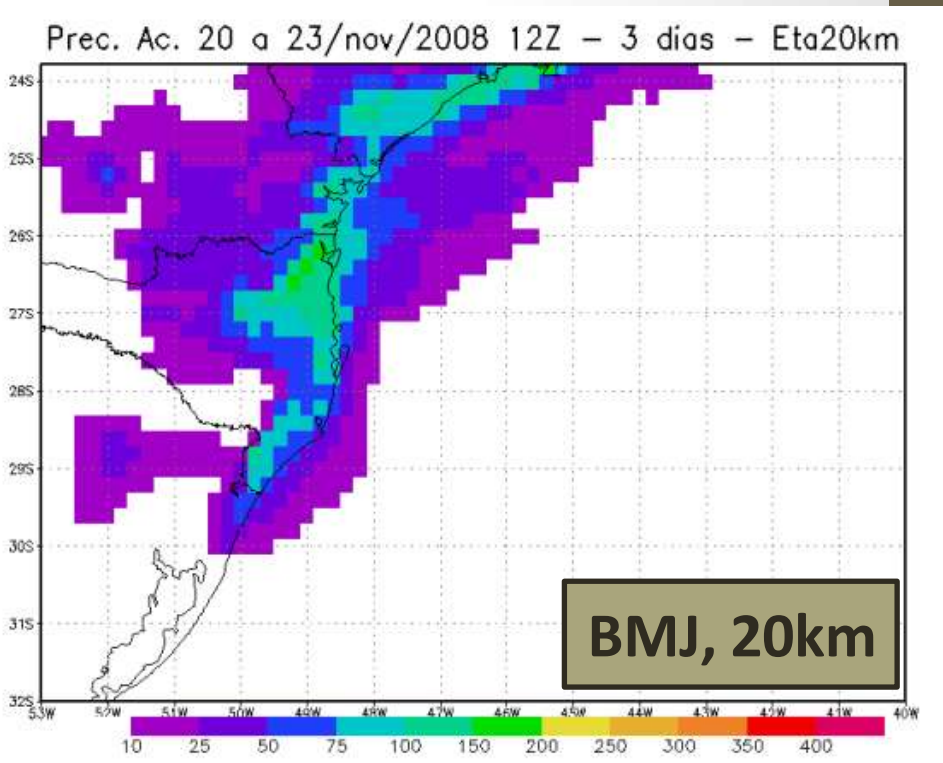


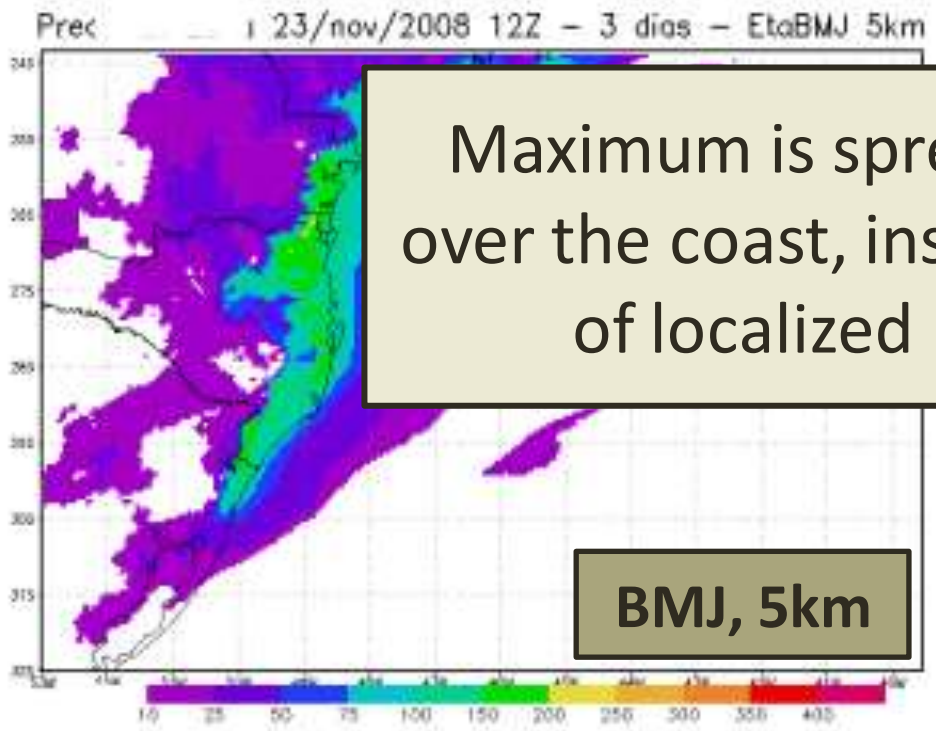




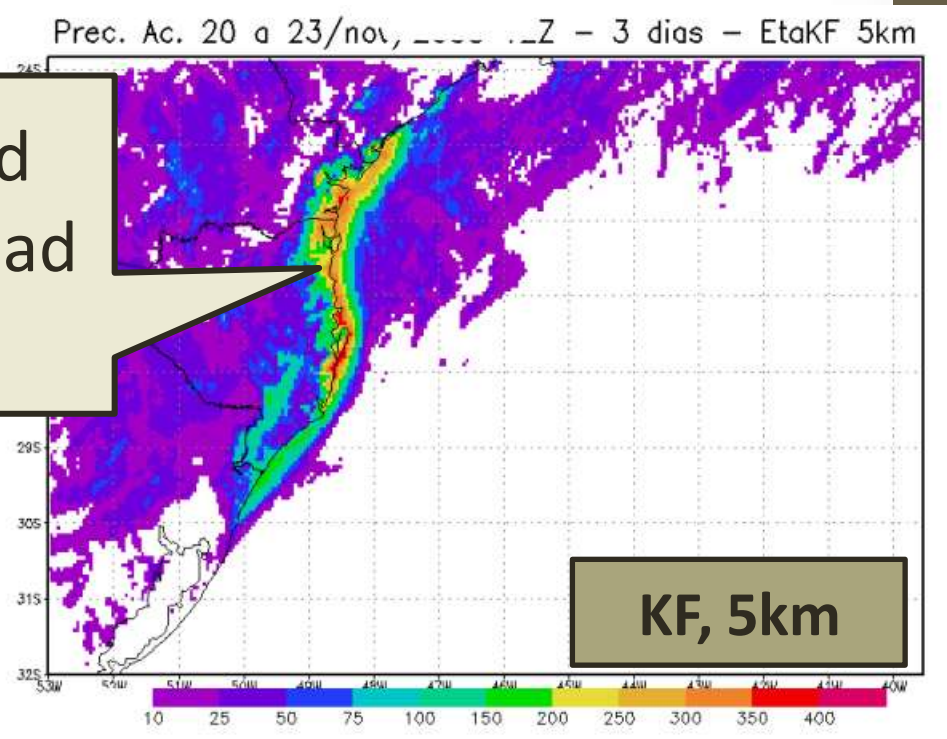
ETA Model, After the fact

- Increasing the resolution and changing the parameterization





Maximum is spread over the coast, instead of localized



Approach – BRAMS model

Testing:

- Different resolution/grids simulations
- Topography, cumulus parameterizations and microphysics effects

Model:

- Brazilian RAMS, same microphysics (Meyers et al., 1997, two moment bulk microphysics)
- CCN set to 500 #/cc – and kept constant
- Prognostic cloud water, rainwater, snow and ice
- Forced by CPTEC Global Model Analysis

Simulation 1 – Coarse Vertical

Vertical

- dz_0 = 120 m
- dz stretch ratio = 1.2
- dzmax = 1000m, 32 levels

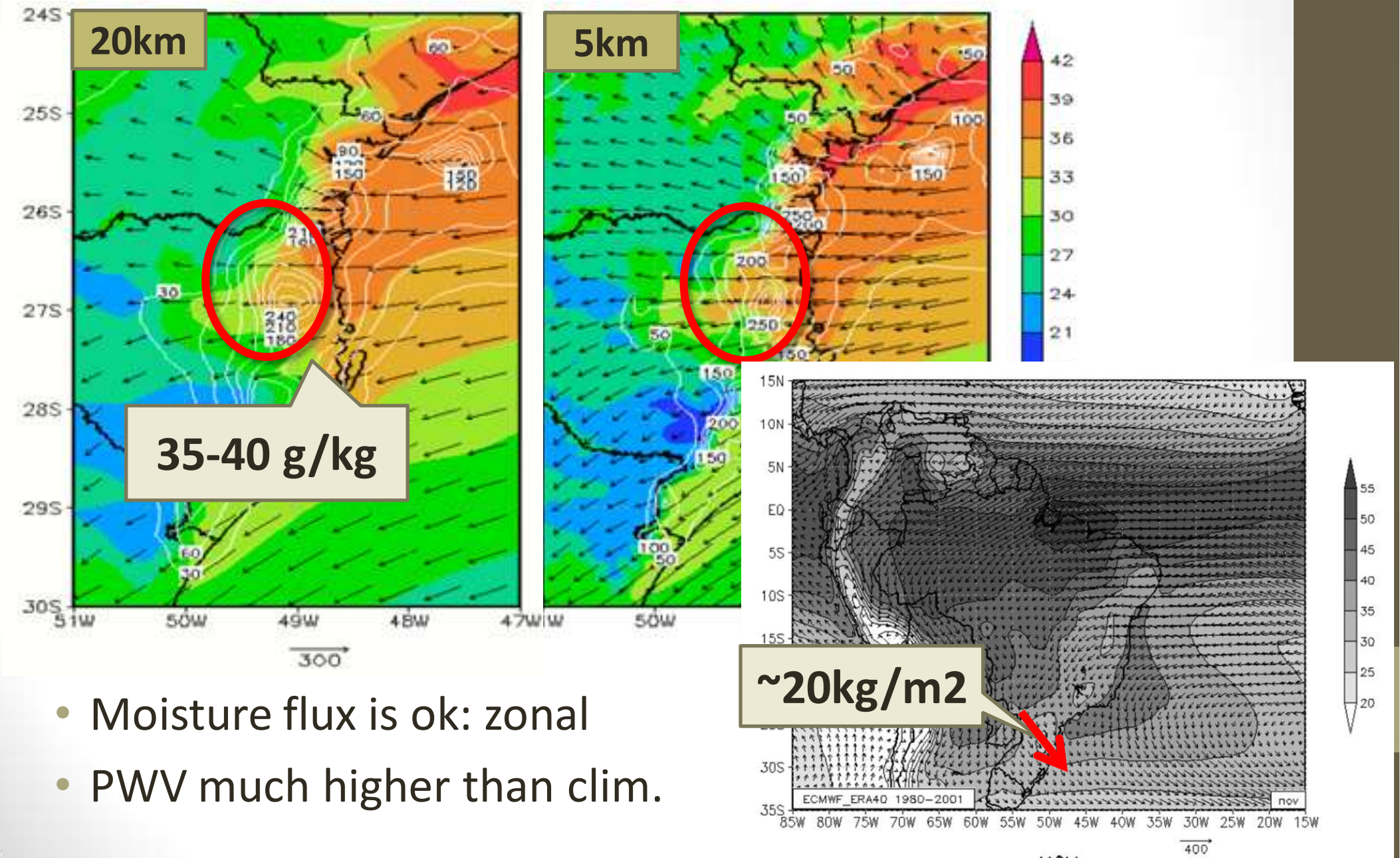
Horizontal

- 2 grids= 20km / 5km
- Topo = 10km / 1km

Physics

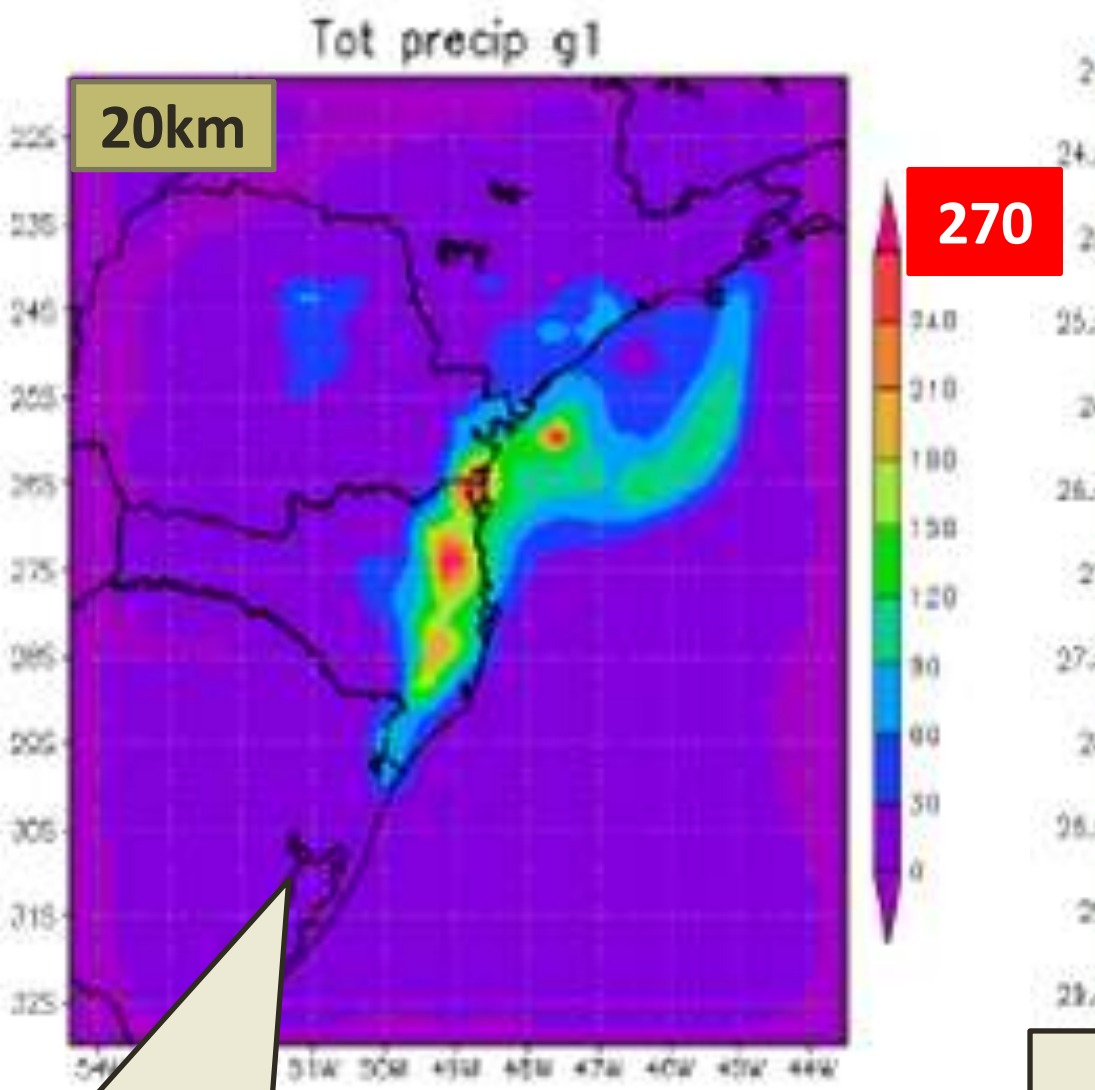
- Grell scheme (grid 1)
- Microphysics (all grids)

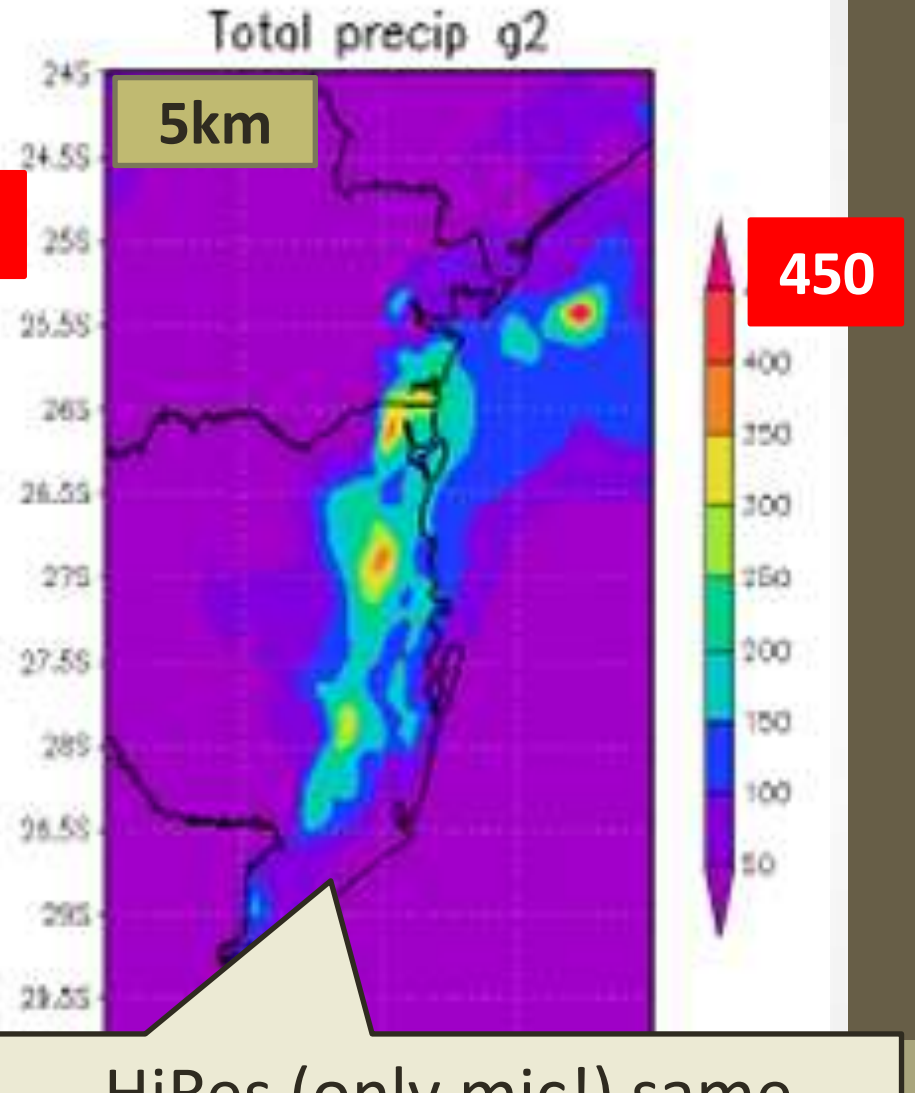
Moisture transport and PWV



- Moisture flux is ok: zonal
- PWV much higher than clim.

Precipitation 20-24 nov

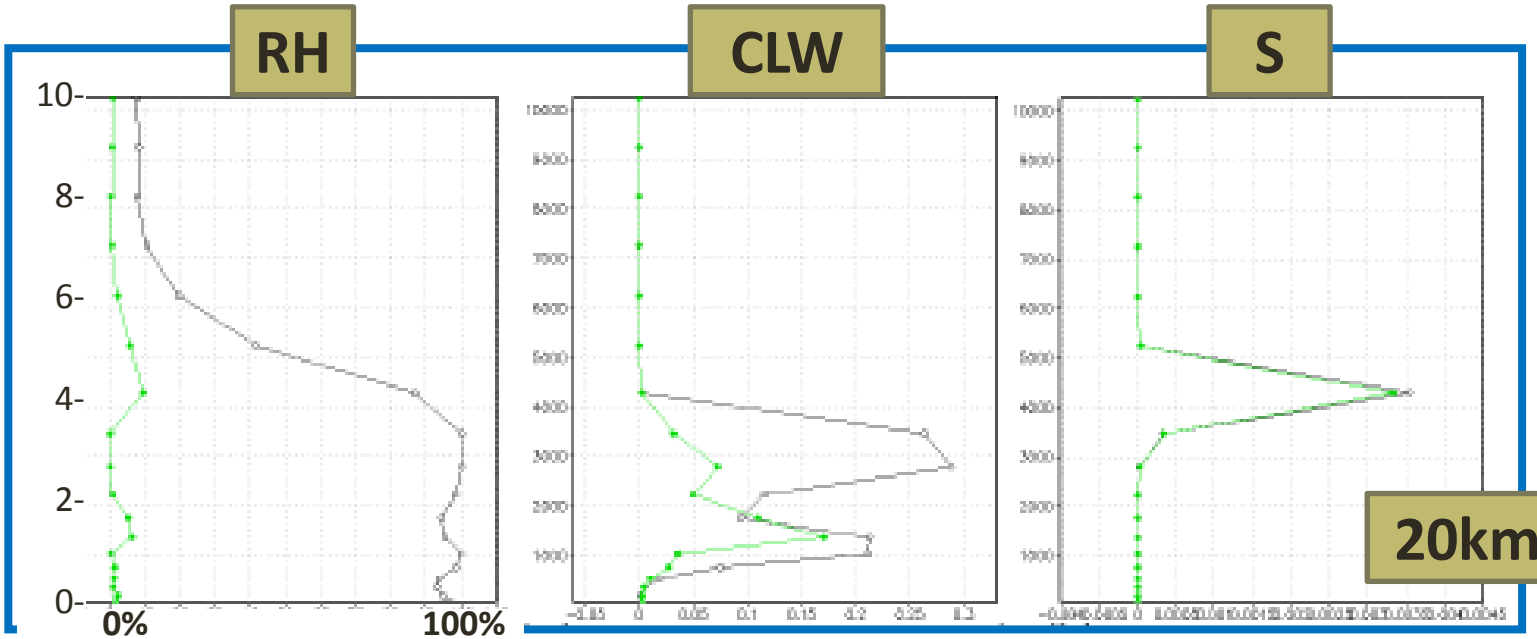


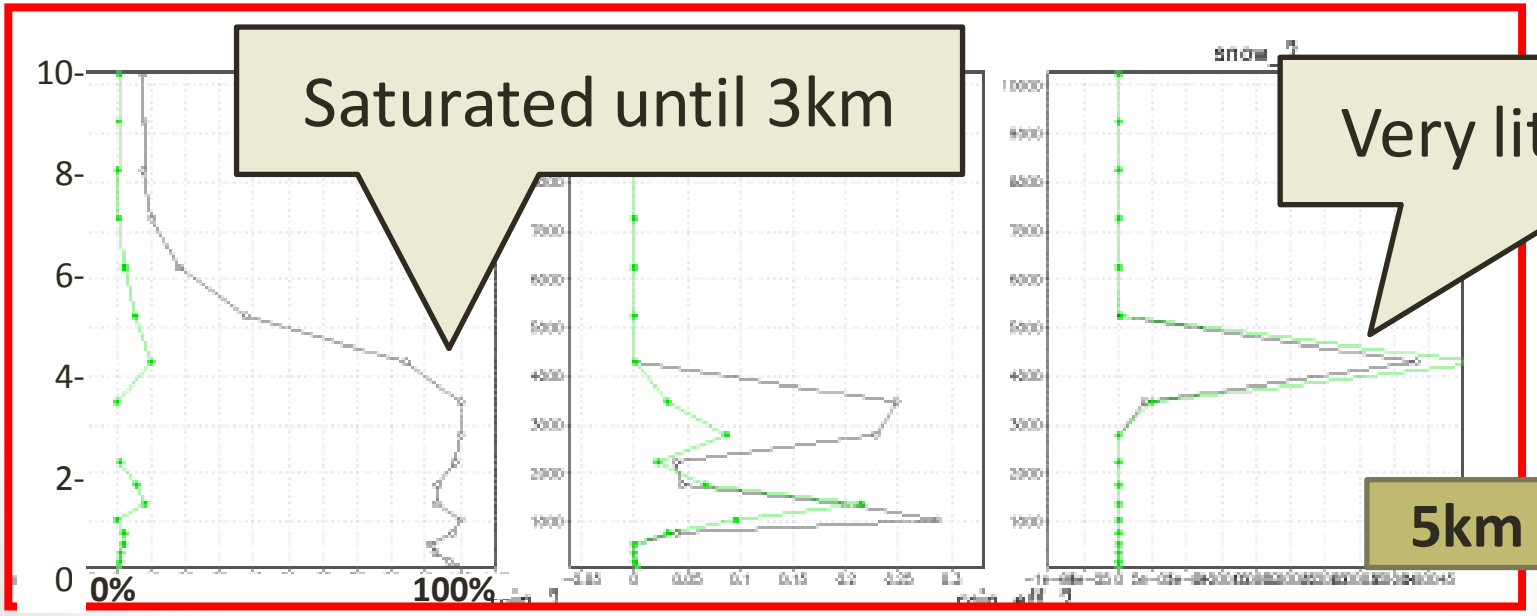


Good agreement in spatial distribution

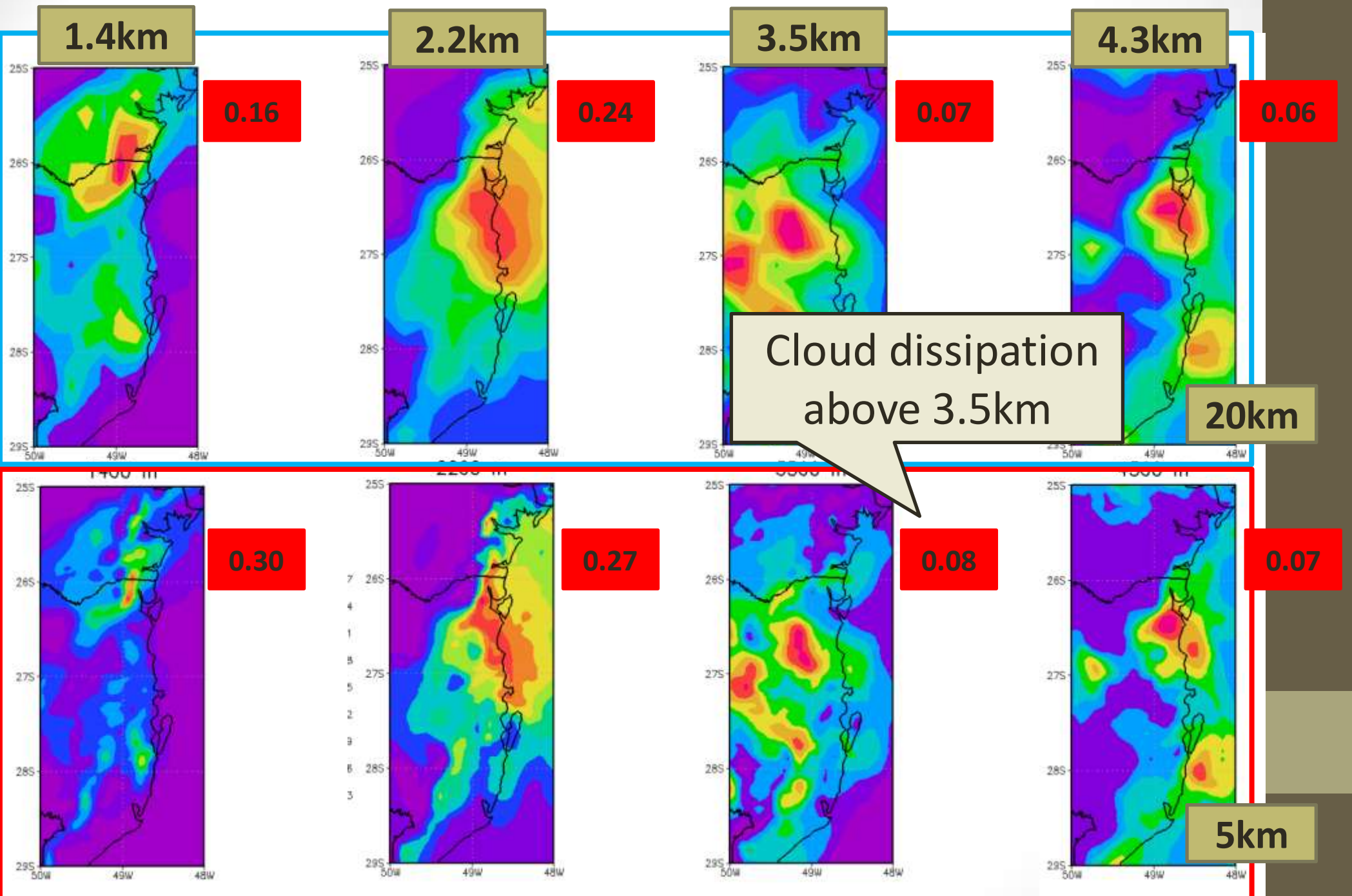
HiRes (only mic!) same spatial distribution and increased total precipitation

Vertical profiles – 21-24nov averages

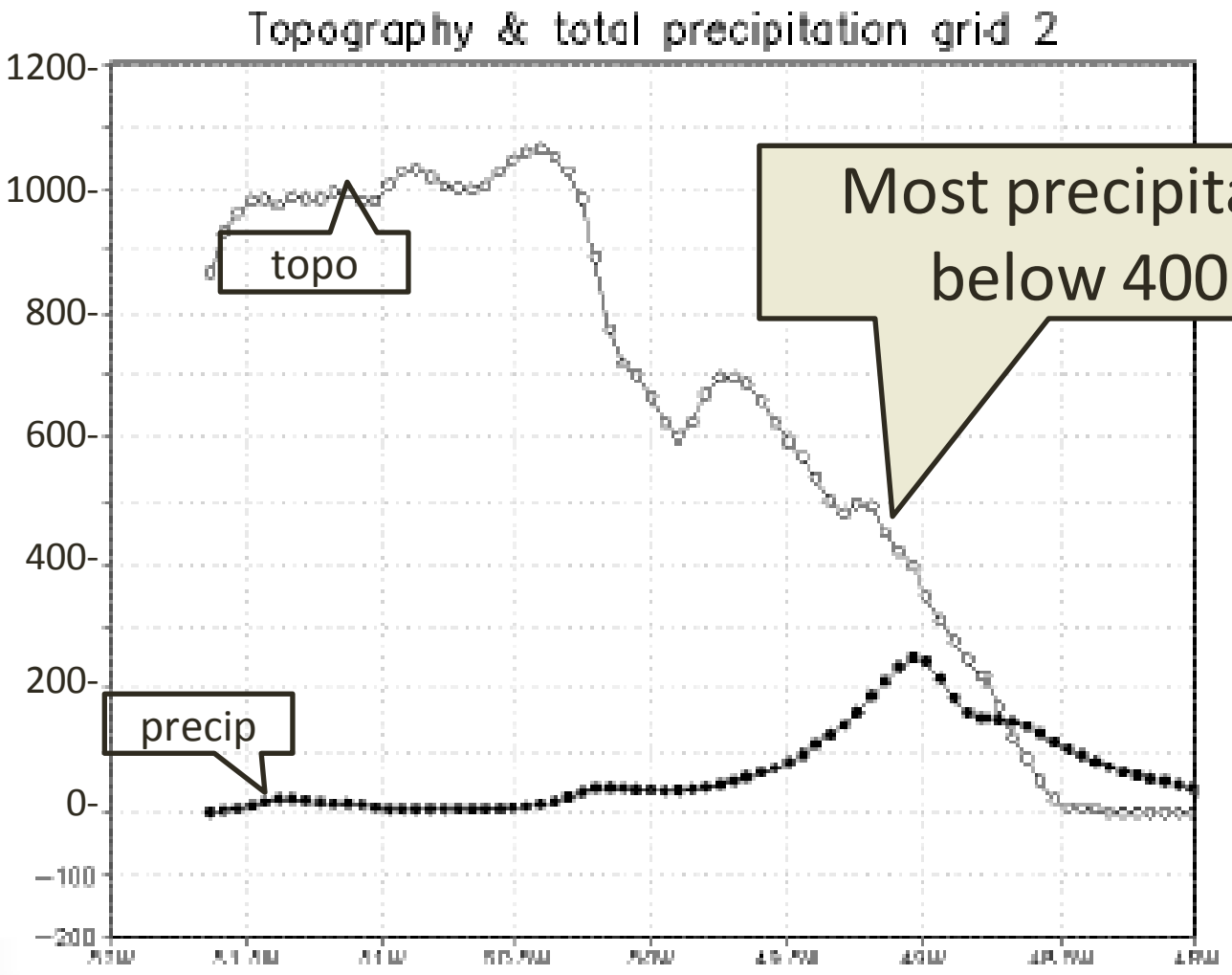




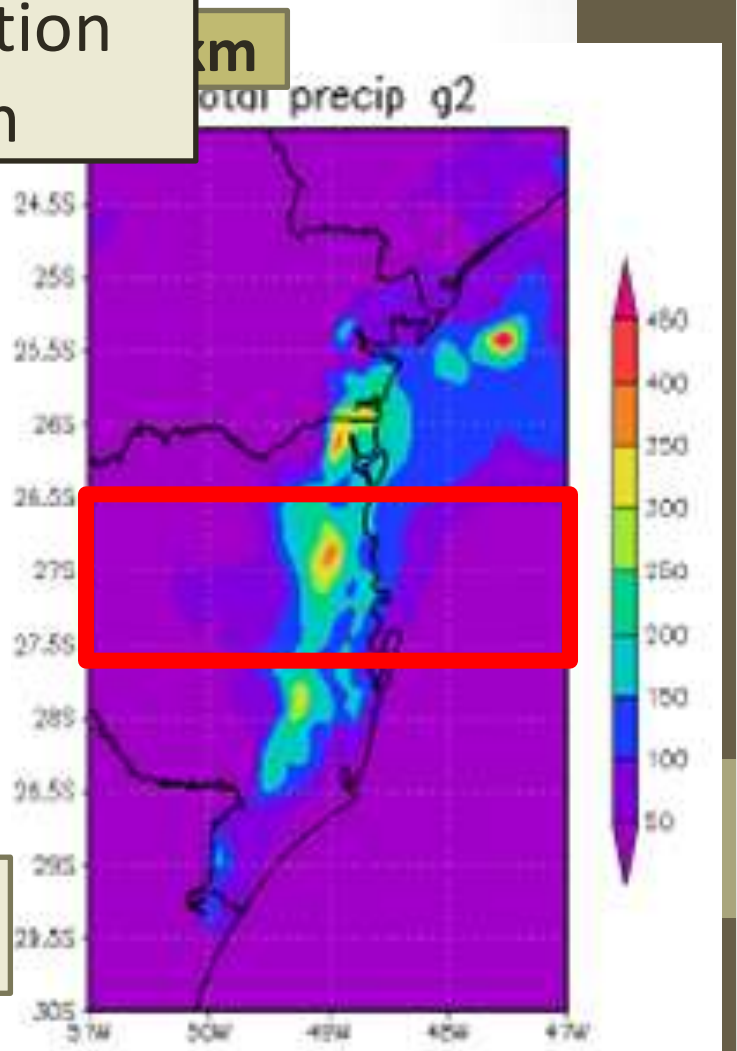
Cloud water (g/kg) – Horizontal Slices



Topography and precipitation



Most precipitation below 400m



West Land

East Ocean

Partial conclusions

- Moisture transport from ocean to land, mostly zonal, is well captured at both 20 and 5km
- Maximum of precip in NE coast of Santa Catarina (~500mm) is
  - Understimated at 20km (270mm)
  - Not so much at 5km (400mm)
- Vertical resolution might be an issue, as most precip falls below 400m altitude

Simulation 2 – Fine Vertical

Vertical

- dz_0 = 120 m
- dz stretch ratio = 1.2
- dzmax = 1000m, 32 levels

Horizontal

- 2 grids= 20km / 5km
- Topo = 10km / 1km

Physics

- Grell scheme (grid 1)
- Microphysics (all grids)

Vertical

- dz_0 = **60 m**
- dz stretch ratio = **1.15**
- dzmax = **500m, 37 levels**

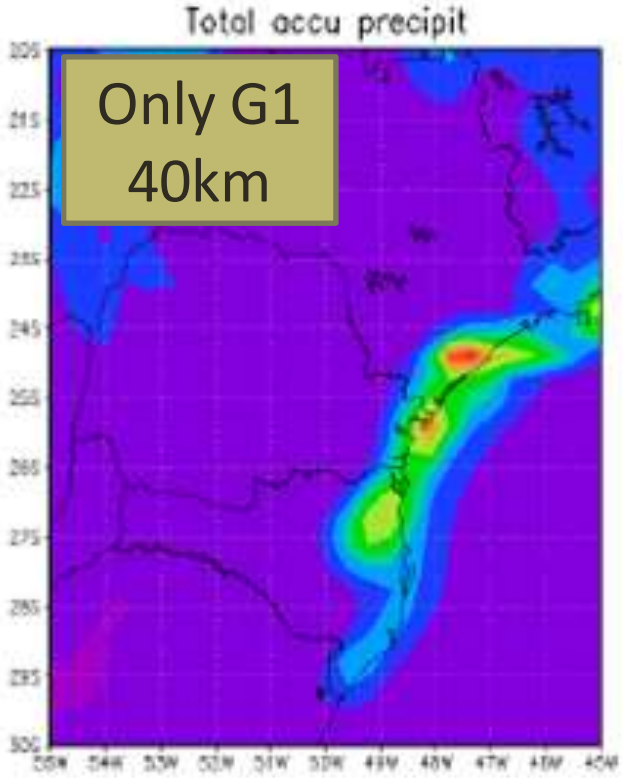
Horizontal

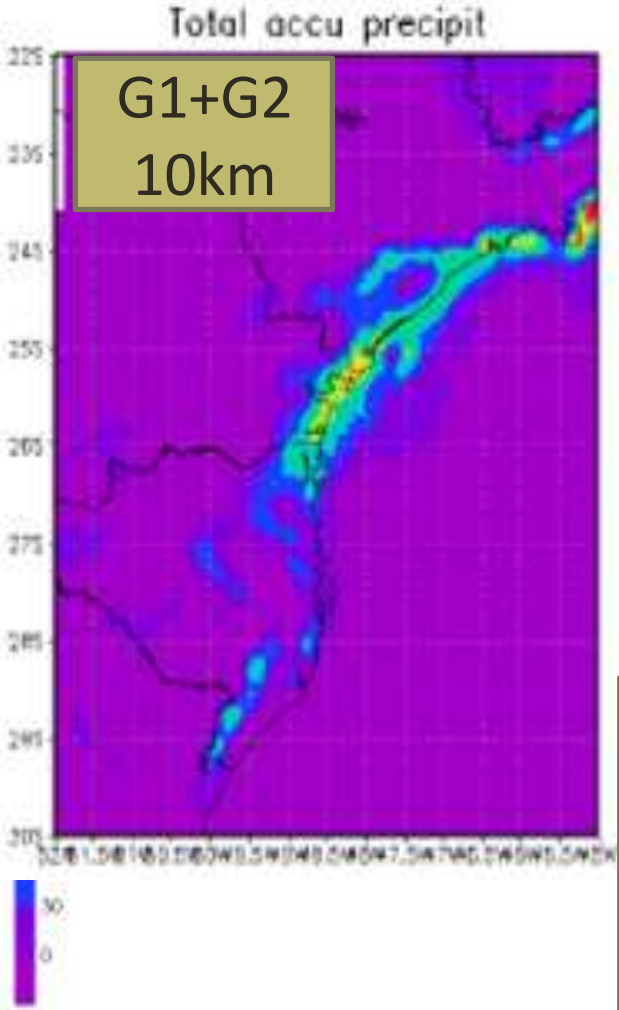
- 3 grids= **40 / 10 / 2.5km**
- Topo = **10km / 1km / 200m**

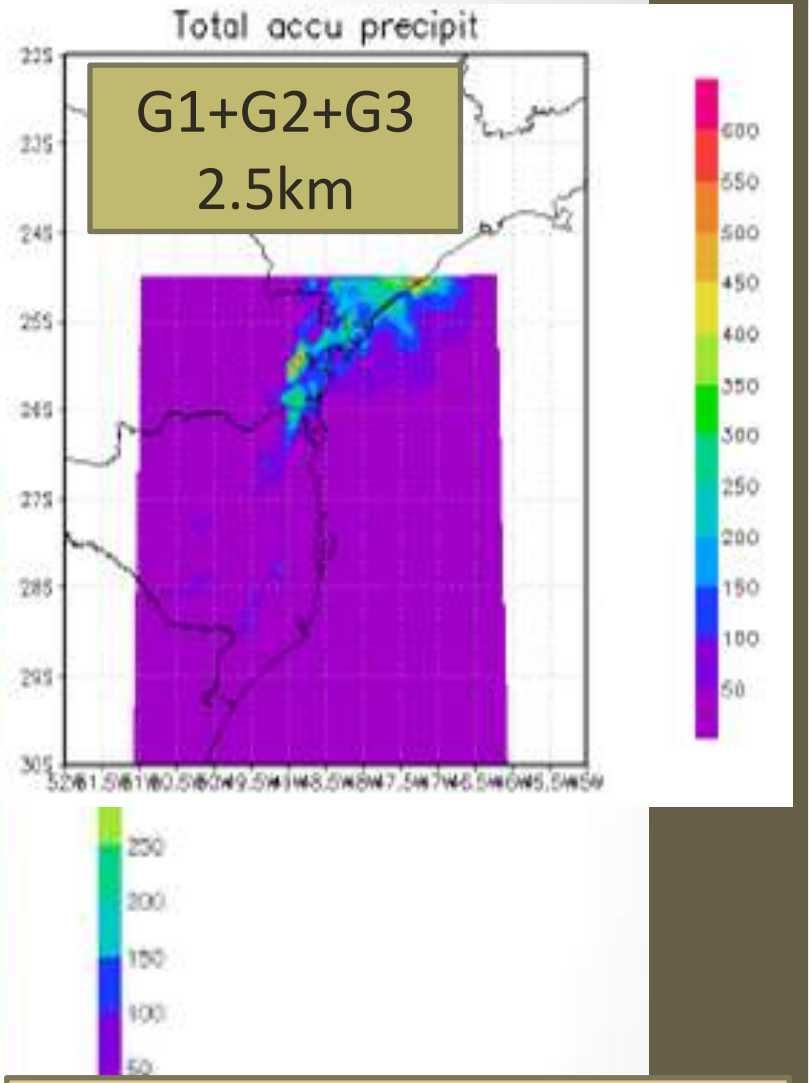
Physics

- Grell scheme **(grid 1, 2**)
- Microphysics (all grids)

Precipitation

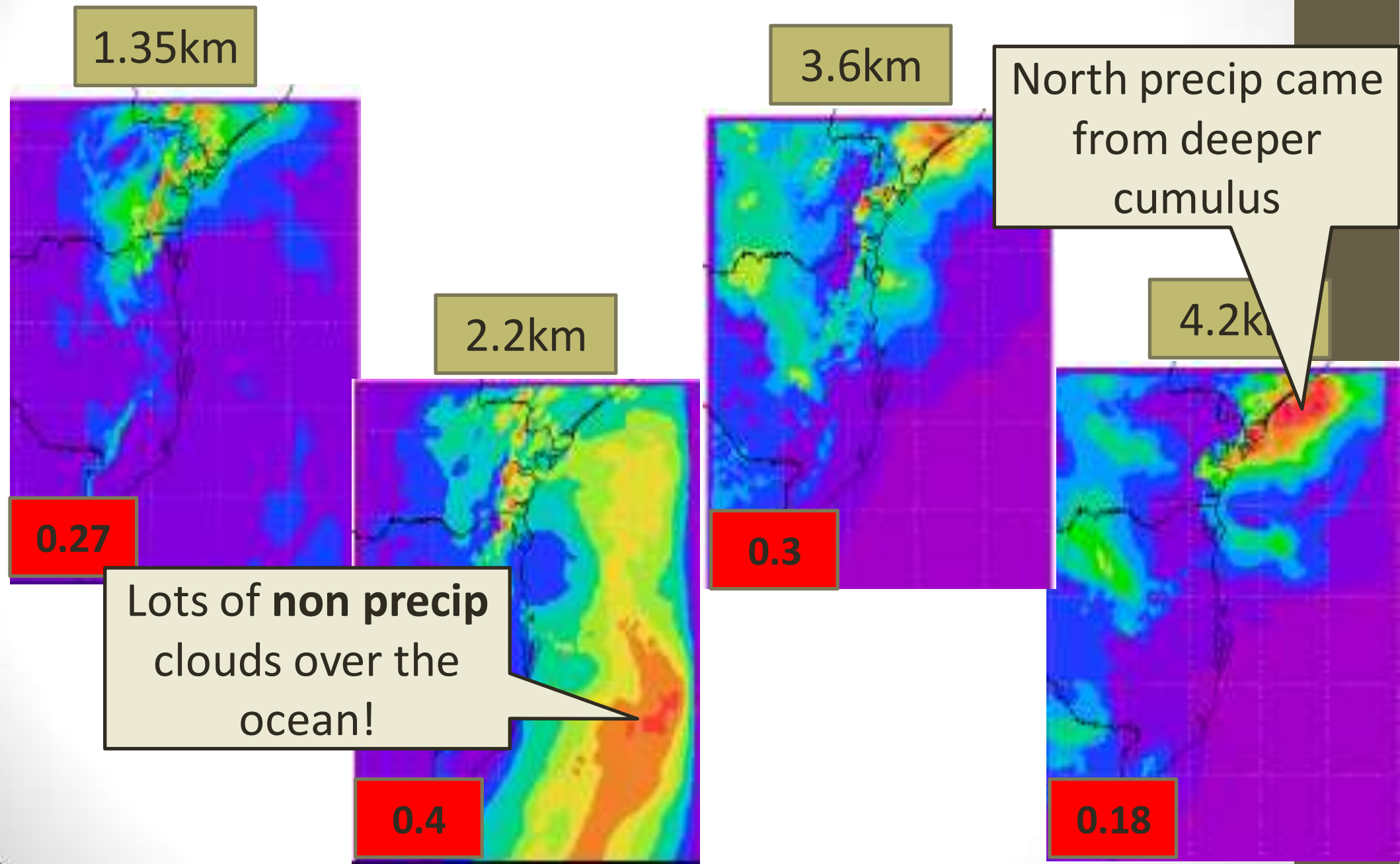




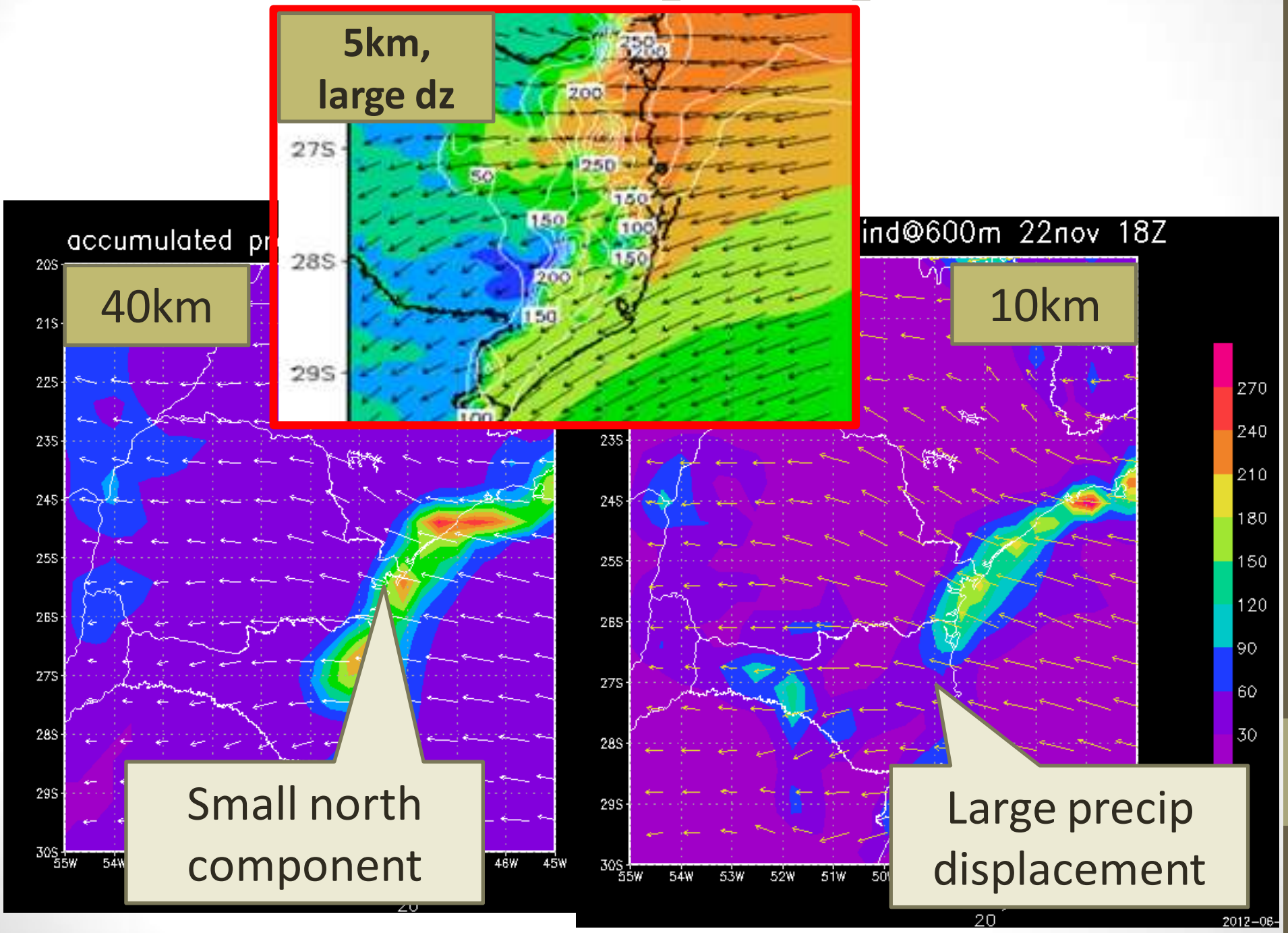


Why increasing resolution/add grids makes precipitation worse?

Cloud water (g/kg) – 2.5km grid

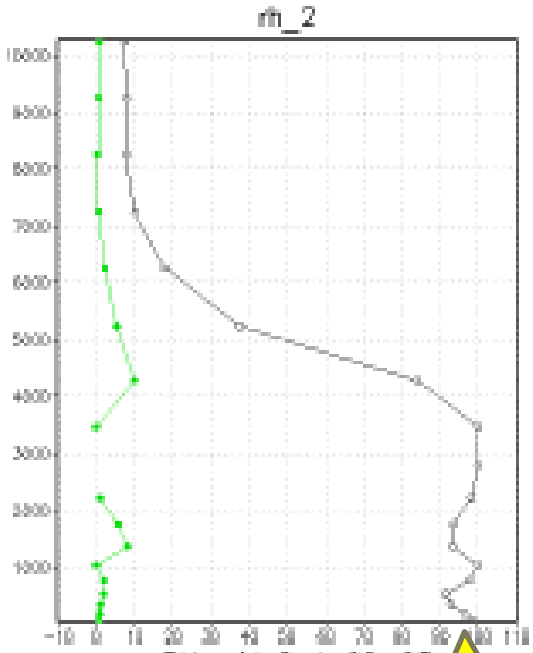


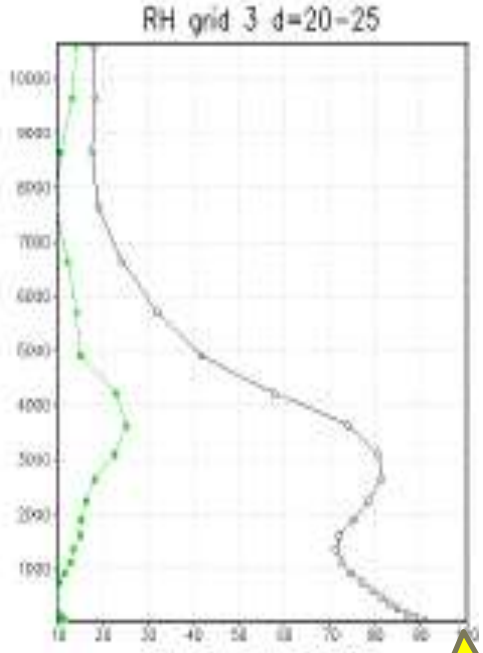
Wind 600m and precip



Mean RH profiles 20-24 Nov

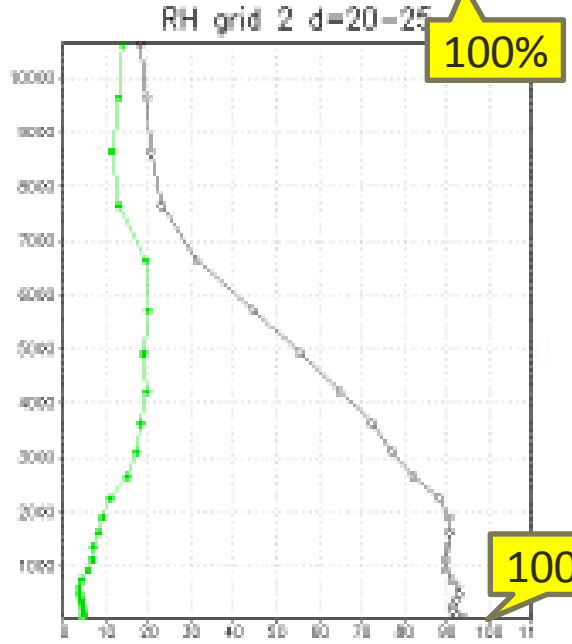
5km
Big dz

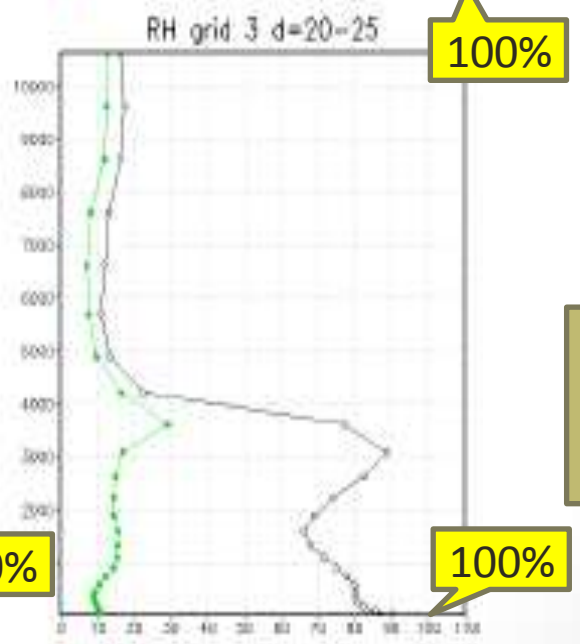




2.5km
Small dz
All Topo 10km

10 km
Small dz
Only the two coarse grids



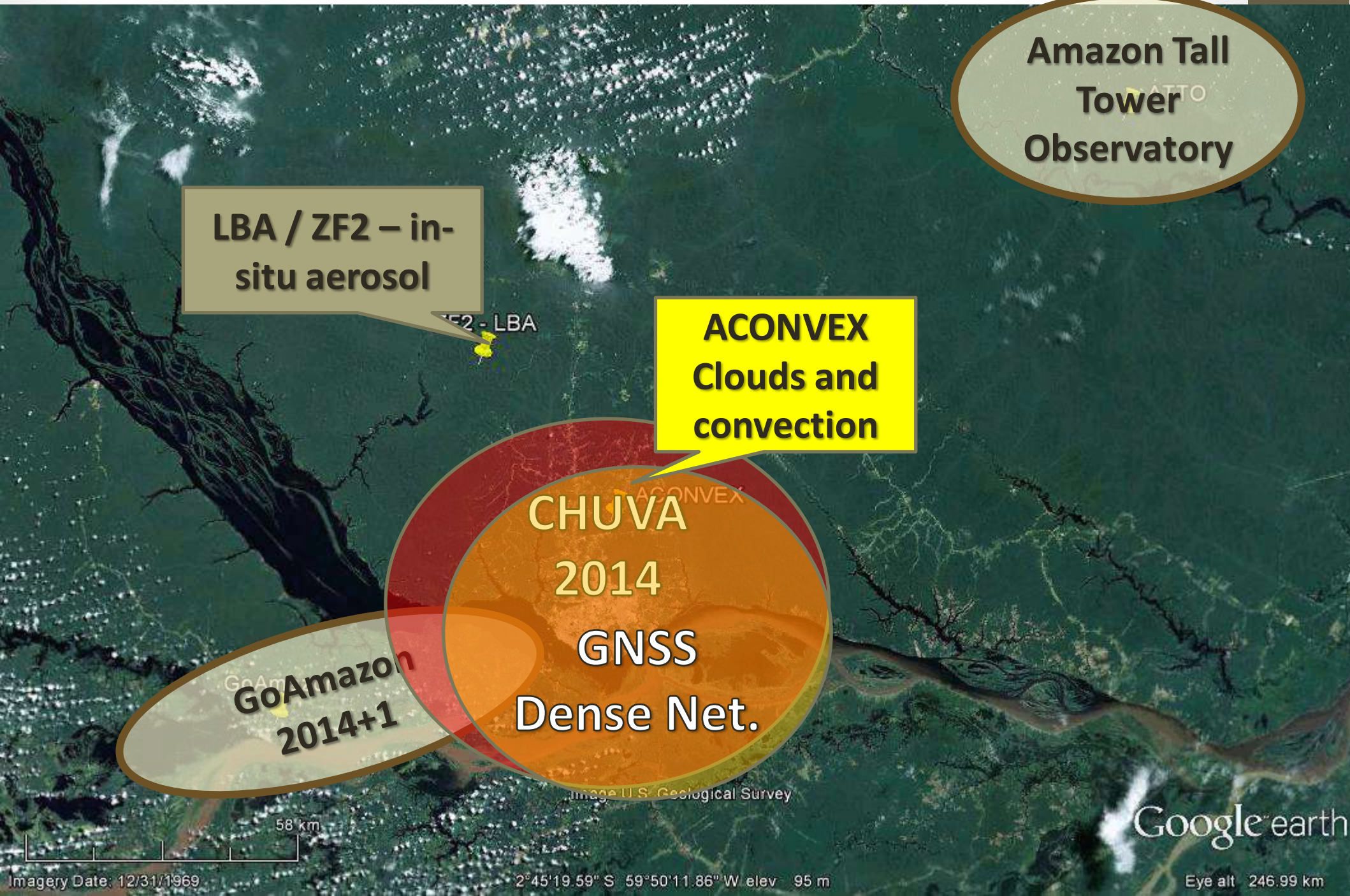


2.5km
Small dz

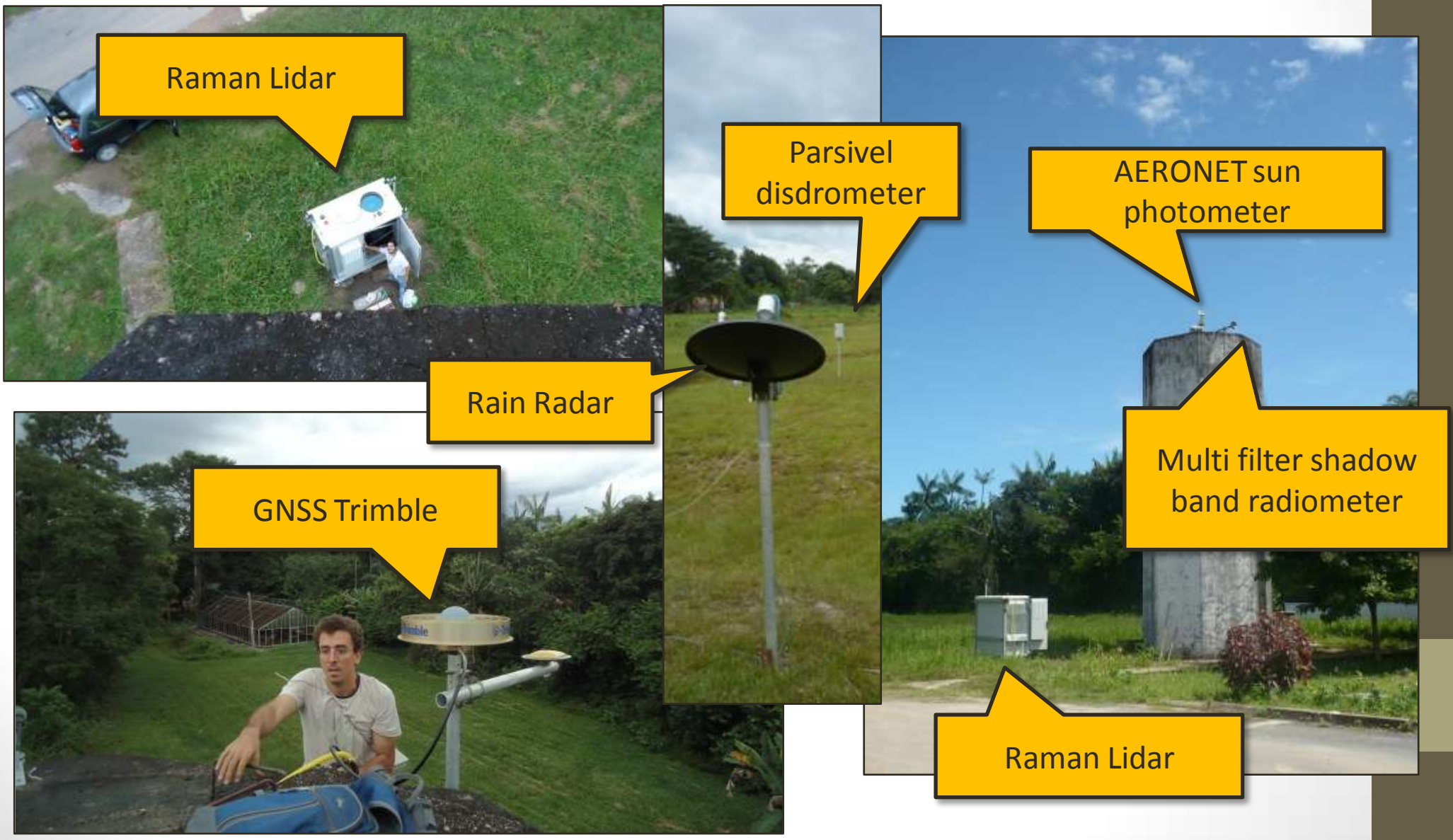
Conclusions??

- Could the extra outer grid at 40km have moved the boundary conditions too far out?
  - **We are doing a series of simulation with various domain sizes**
- How could decreasing Δz ruin the vertical profile?
  - **We are checking surface fluxes, turbulence, etc…**
- Why in a 3-grid simulation, precip at 40km looks better than at 2.5km?
  - **We are checking how much the shallow clouds over the ocean are reducing evaporation**
- Of course our plan was to go much below 2.5km, but does not make sense if results are getting worse

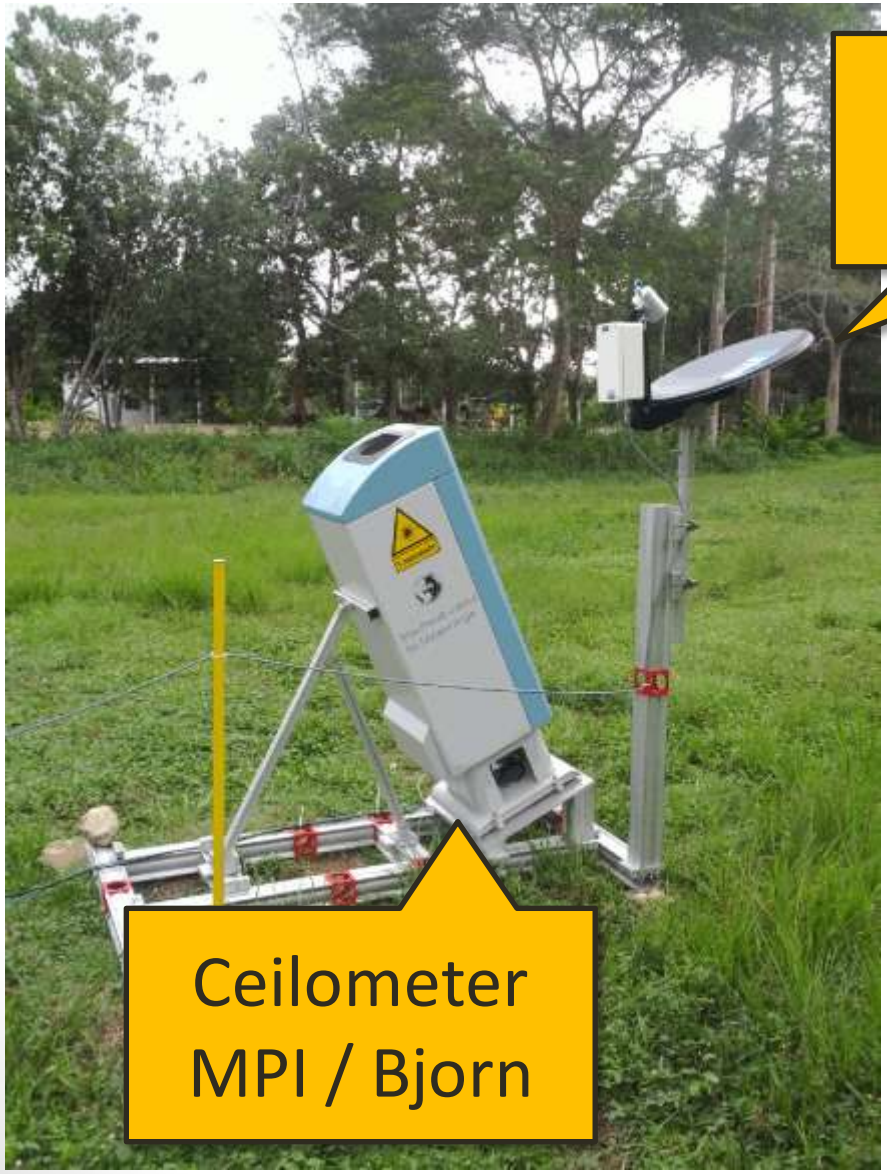
Some Research Plans in the Amazon



ACONVEX – Aerosol, Clouds, Convection Experiment



ACONVEX – Aerosol, Clouds, Convection Experiment



CONCEPT:

Collaborative research site. Already 4 different projects involving 7 institution contributed instruments.

Interested to put an instrument there? Contact me!

Lots of FUN!

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