Modeling clouds at high resolution: cloud forecast verification with satellite observation

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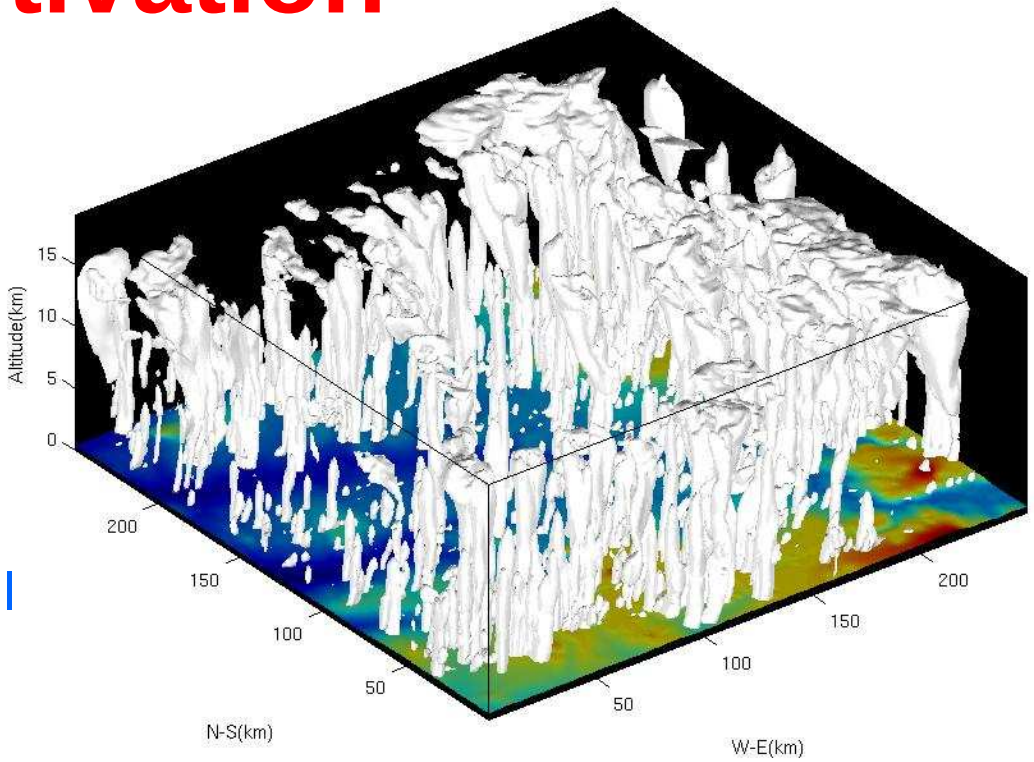
(presented by Patrick J. Mascart)

Motivation

CRM = cloud resolving model (Δx~1 km), explicit representation of cloud system circulation



Simulated cloud field over Brazil (TROCCINOX 2005, Bauru)

- **Identification of systematic errors in parameterizations**
  e.g. mixed-phase cloud microphysics
- **Improvement of cloud forecasts,** clouds affect the radiation budget and can produce rain

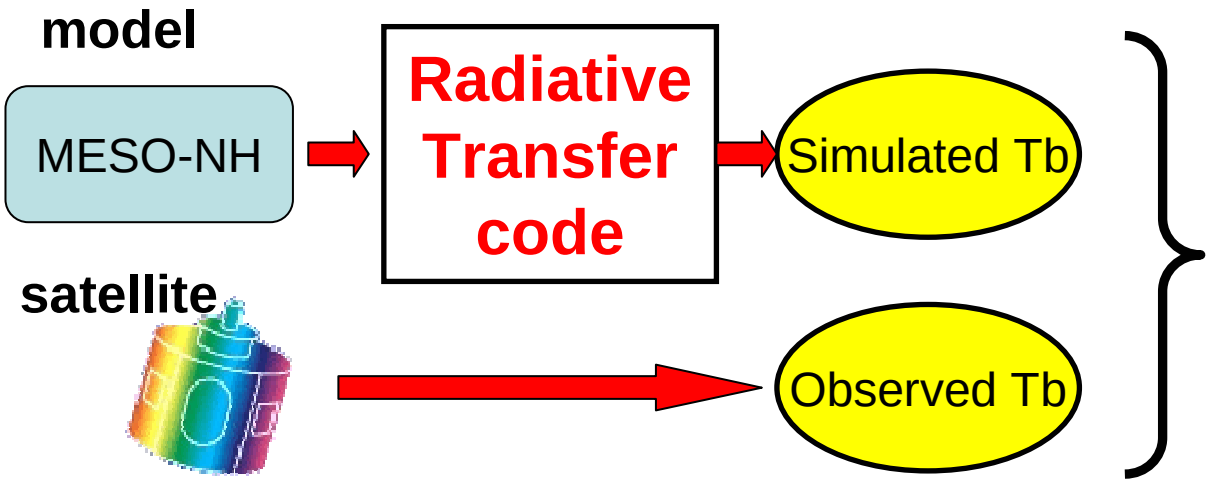
Méso-NH

A state of the art research model

- Jointly developed by Météo-France and CNRS
- Non-hydrostatic (Δx = 100 km – 10 m), anelastic system
- A large number of parameterizations
  - Physics: radiation, turbulence, deep and shallow convection parameterization, statistical cloud scheme, mixed-phase microphysics (5 species, 35 processes) .
  - Chemistry & aerosols in gas and aqueous phases
  - Coupling with ocean, hydrology, electricity, etc.
- Run on real and idealized conditions: 1D, 2D, 3D, nesting
- Post-processing and diagnostics packages
  - budgets, profilers, trajectories, satellite, radar, lidar, GPS
- MPI-Parallelized (PC cluster to SGI-ICE, IBM-SP, IBM-BG)

More on http://mesonh.aero.obs-mip.fr/

Our approach: model to observation



- Quantitative comparison with scale similarity

- ❖ IR: RTTOV (parameterization)
- ❖ MW: ATM (int. size dist.)
- ❖ Active: Home-made (int. size dist.)

- ❖ High clouds (Tb 10.8 µm)
- ❖ Clouds/precip (183 to 37 GHz)
- ❖ Cirrus/dust (ΔTb 8.7, 10.8, 12 µm)
- ❖ Overshoots (ΔTb 6.2, 10.8 µm)
- ❖ 3D clouds/precip. (lidar/radar)

An Example: Control of cloud ice

- Key role of autoconversion of ice to snow for ice content control
- False similarity in µ-physics with autoconversion droplets → rain
- However most of the schemes use a Kessler-like formulation

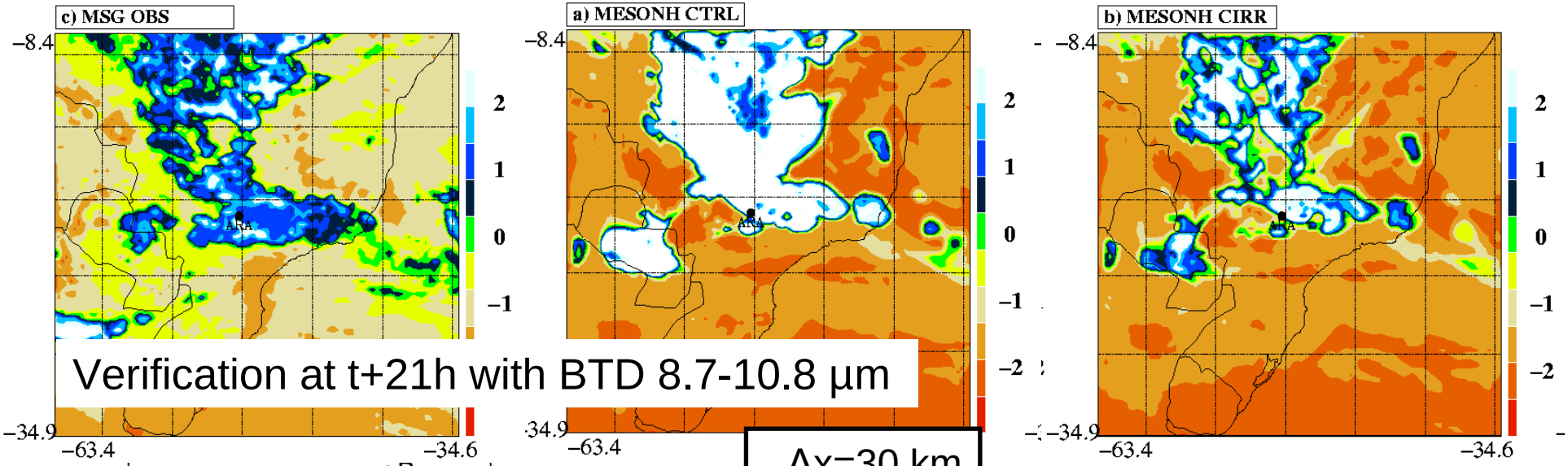
$$R_{iauts} = k_{is} \max\left(0, r_i - r_i^*\right)$$

- inverse time constant: $k_{is}=10^{-3}\, e^{0.015\times T°C}\ s^{-1}$
- critical mixing ratio: $r_i^*= 5.0\ 10^{-4}$ kg kg^{-1}

- literature : $r_i^*= 1.0\ 10^{-5}$ kg kg^{-1} (Fowler et al. 1996)
  $r_i^*= 1.8\ 10^{-4}$ kg kg^{-1} (Hong et al. 2004)

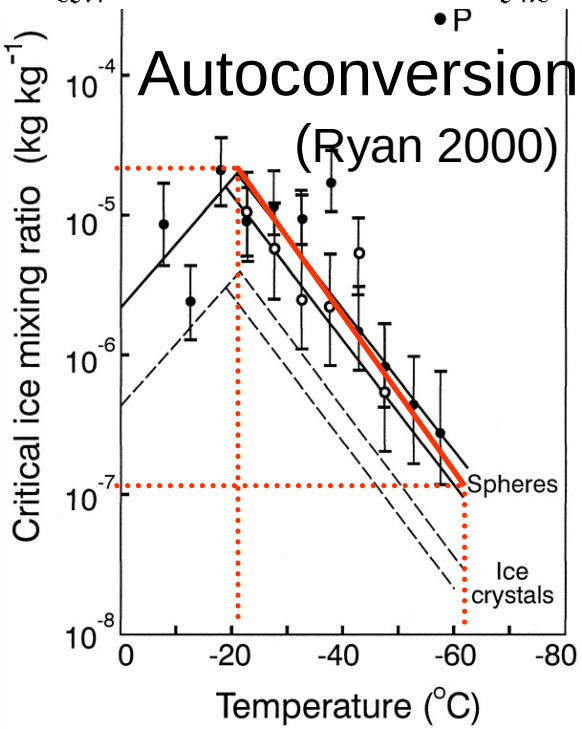
Chaboureau et al., JGR 2002

A refined tuning for cirrus



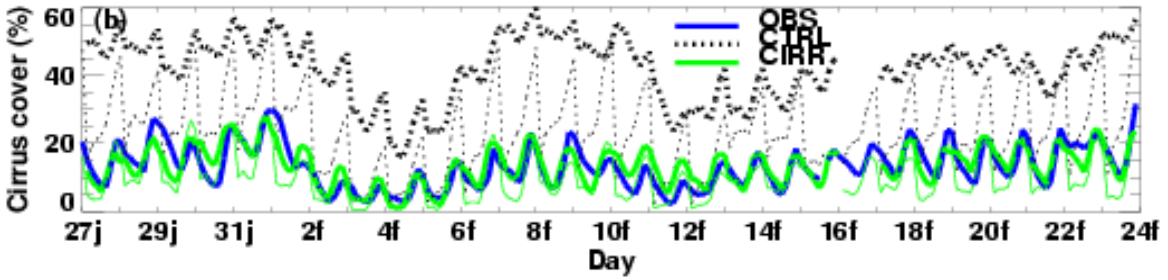
Verification at t+21h with BTD 8.7-10.8 µm

Δx=30 km



$$r_i^* = \min\left(2\times10^{-5}, 10^{0,06\times(T-273,16)-3,5}\right)$$

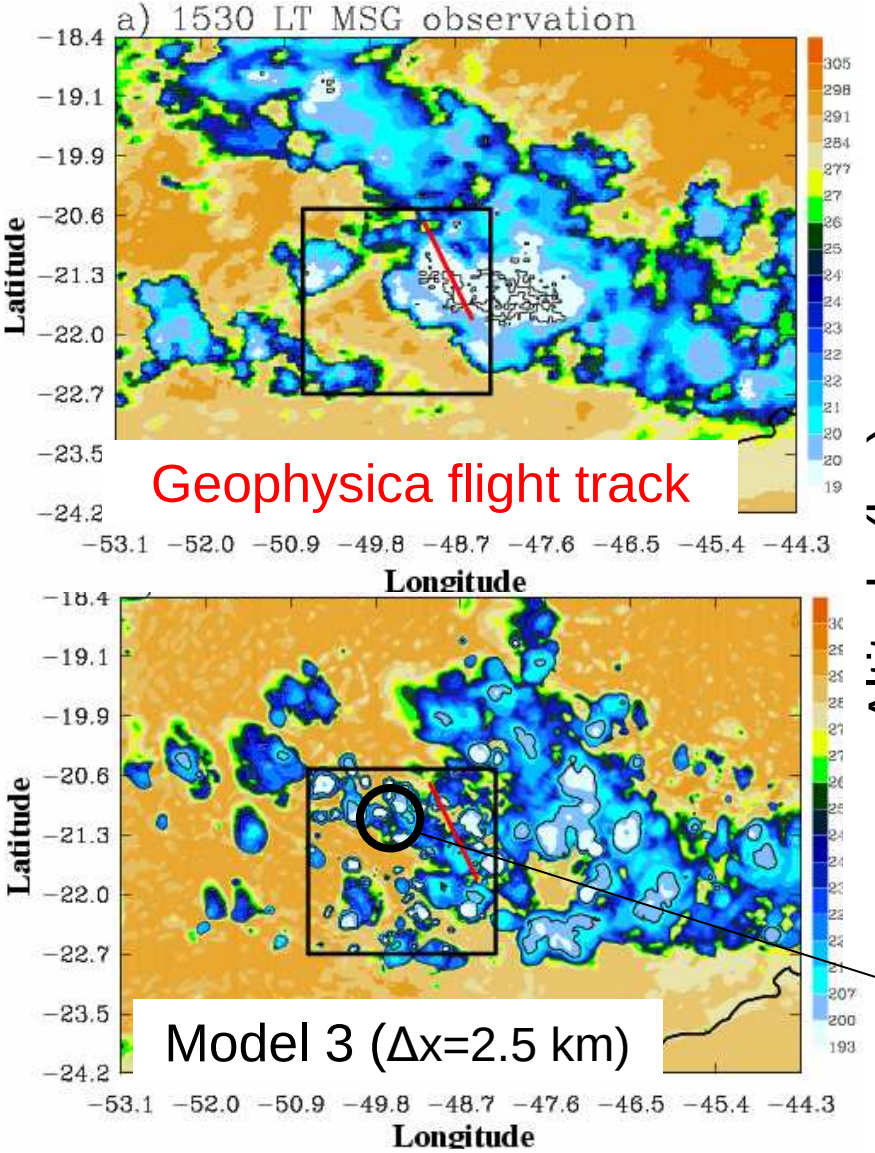
Statistics over 30 days



Cirrus cover defined with BTD>1K

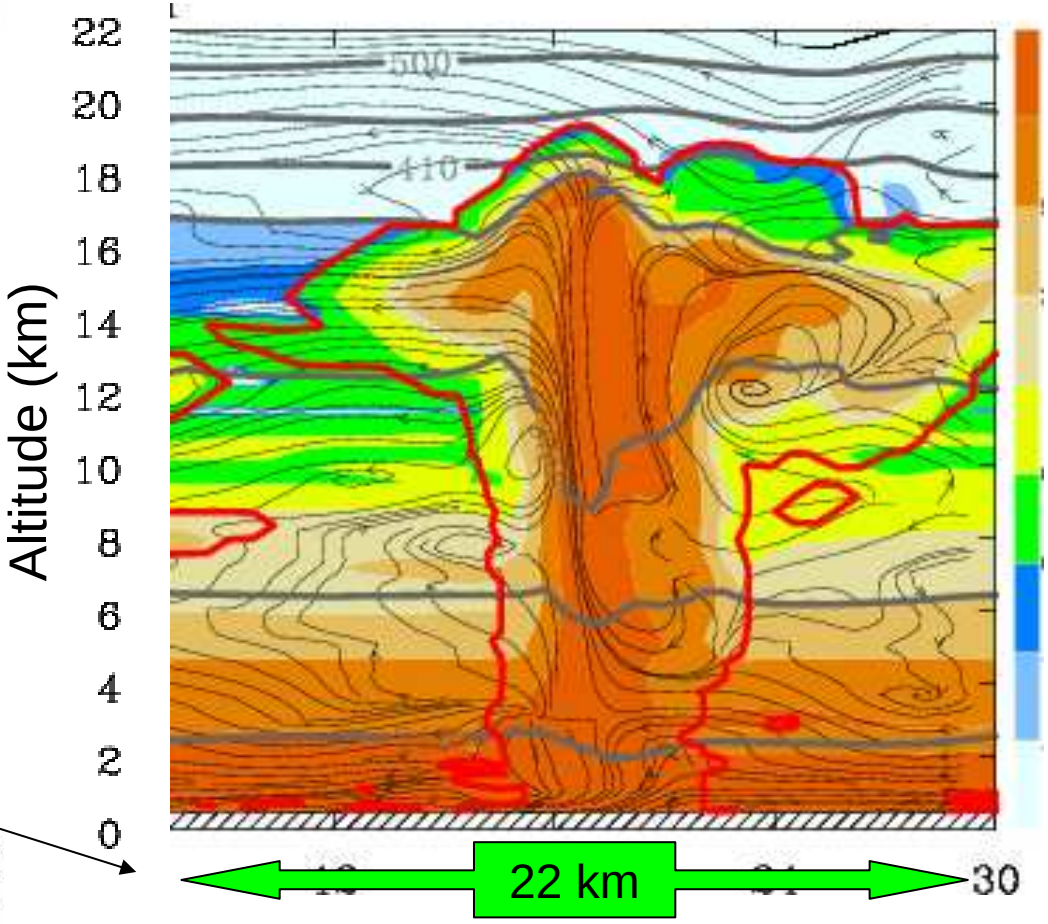
Chaboureau and Pinty, GRL 2006

Convective overshoots in Brazil



Black line: 6.2-10.8 µm BTD=3K
Color: 10.8 µm BT

Model 4 (Δx=625 m)

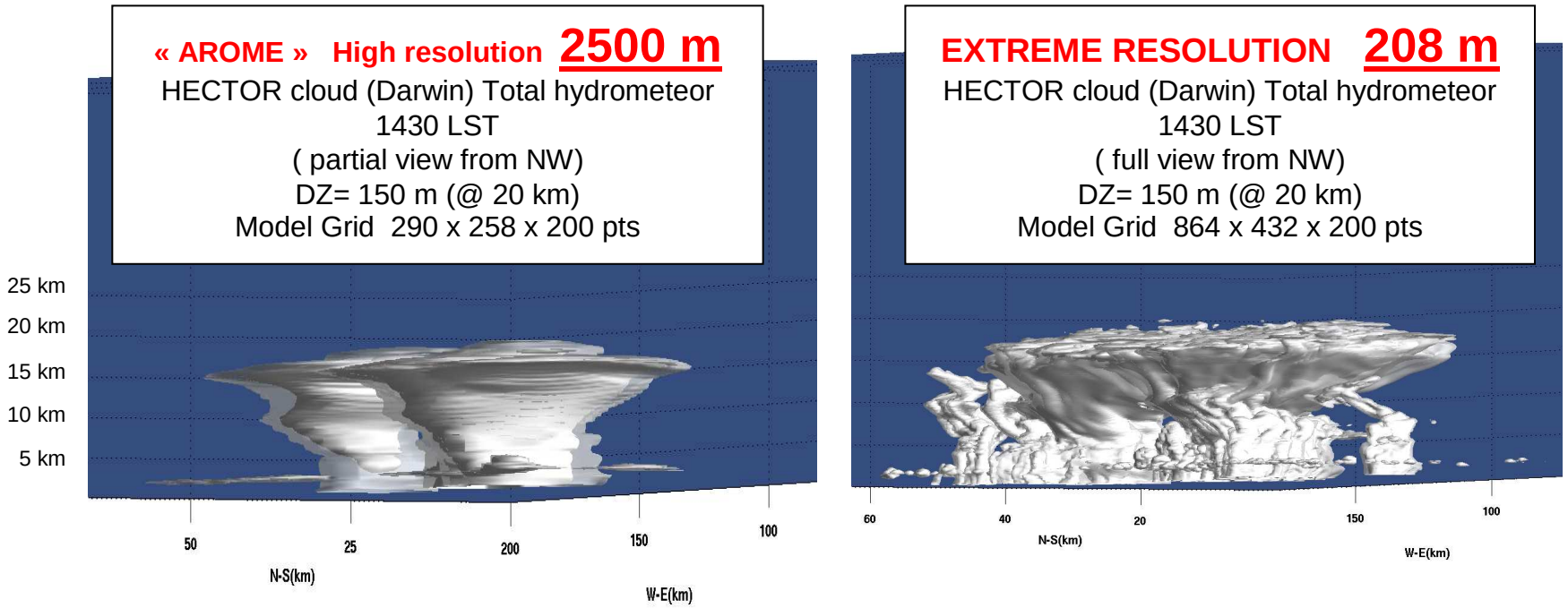


Color: Total water content
Red line: Cloud limit

Chaboureau et al., ACP, 2007

EXPLORING EXTREME RESOLUTION CLOUD MODELING

- Test case: VERY DEEP TROPICAL CONVECTION
- Cloud morphology and detrainment properties strongly depend on resolution



J. P. Chaboureau, J. Duron, 2009

- Are the results mesh-size independent at hectometric mesh-size?

Gracias…