

Better climate modelling with a stratocumulus emulator

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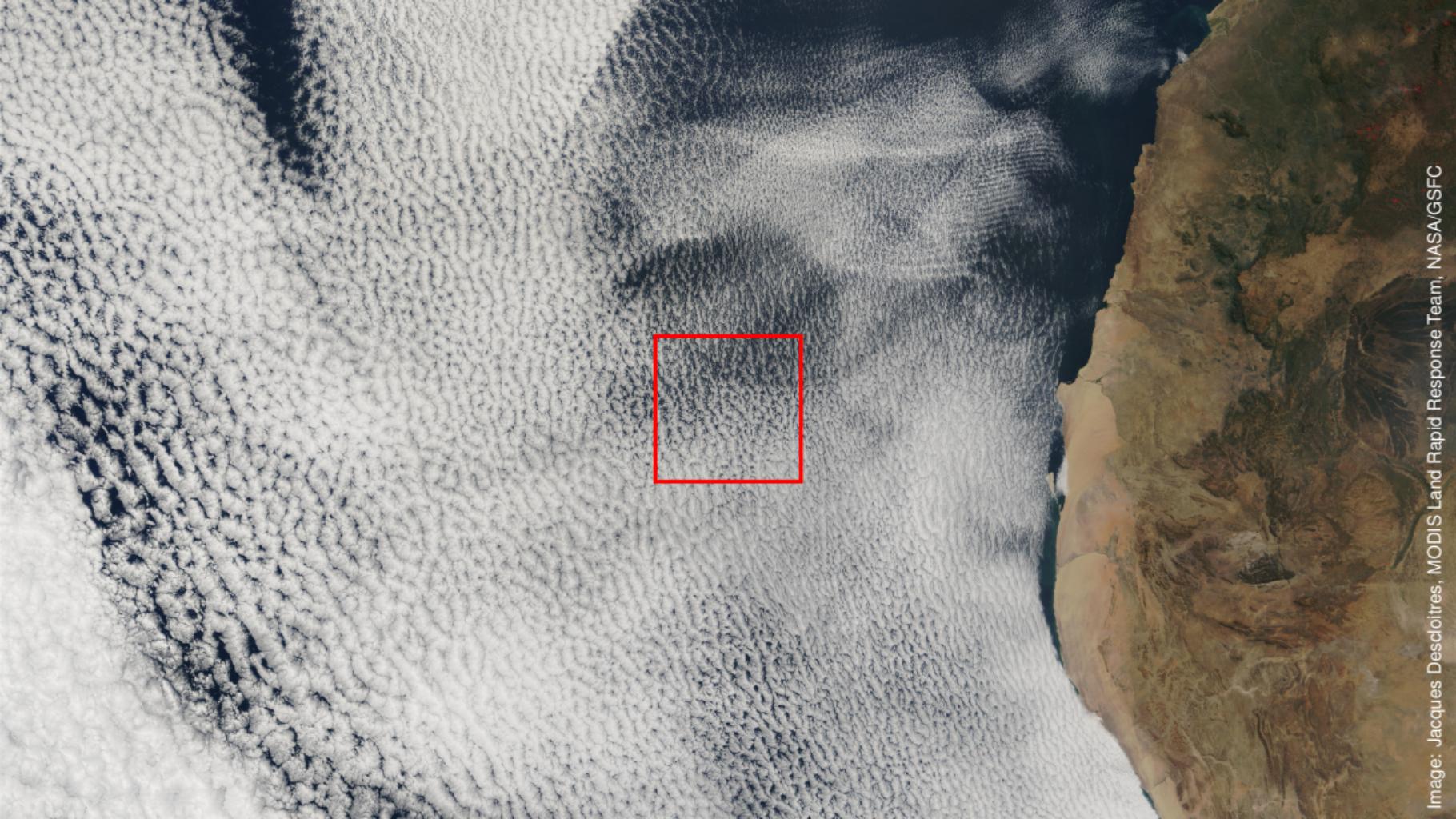
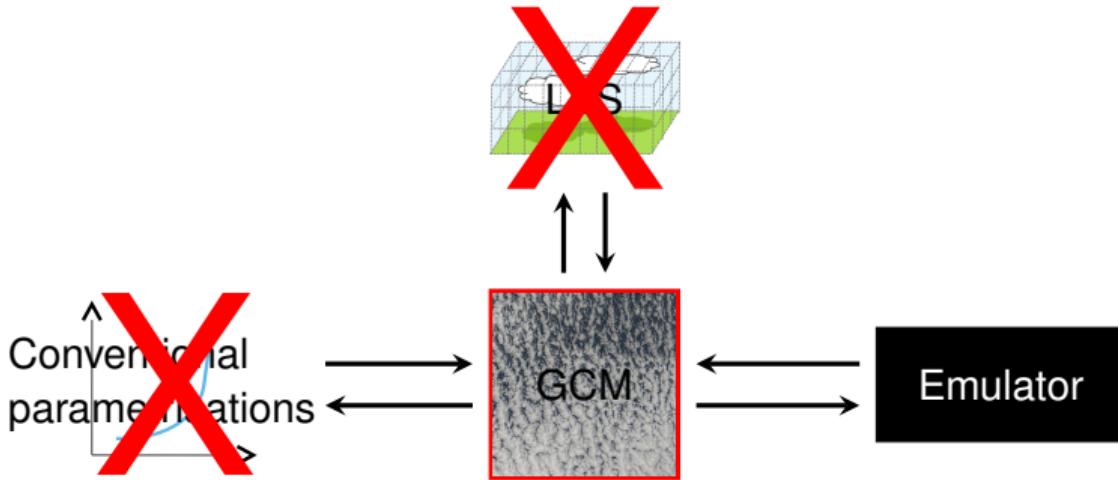


Image: Jacques Descloutres, MODIS Land Rapid Response Team, NASA/GSFC



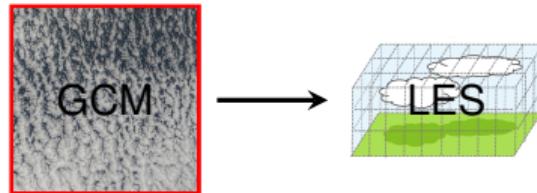
- Emulation of subgrid-scale aerosol-cloud interactions in climate models: towards a realistic representation of aerosol indirect effect (ECLAIR)
- Currently at proof-of-concept stage
- Models: UCLALES, UCLALES-SALSA, and ECHAM-HAM
- Focus on aerosol-cloud interaction



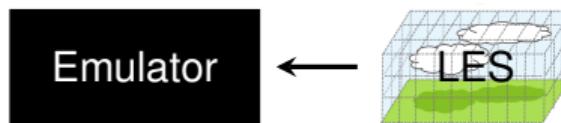
Emulator

- A statistical approximation of the LES
- Based on Gaussian processes (GP)
- GP can be thought as a generalisation of Gaussian probability distributions to functions
- Emulator has to be trained \Rightarrow LES
- Needs ≈ 10 times more training points than input parameters
- In optimal case, emulator has same output as LES with a fraction of computational cost

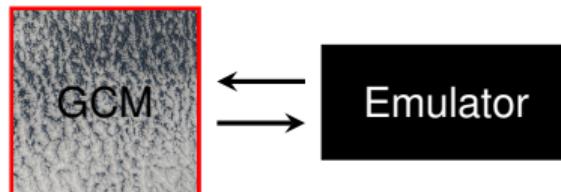
1. Training set creation



2. Emulator training

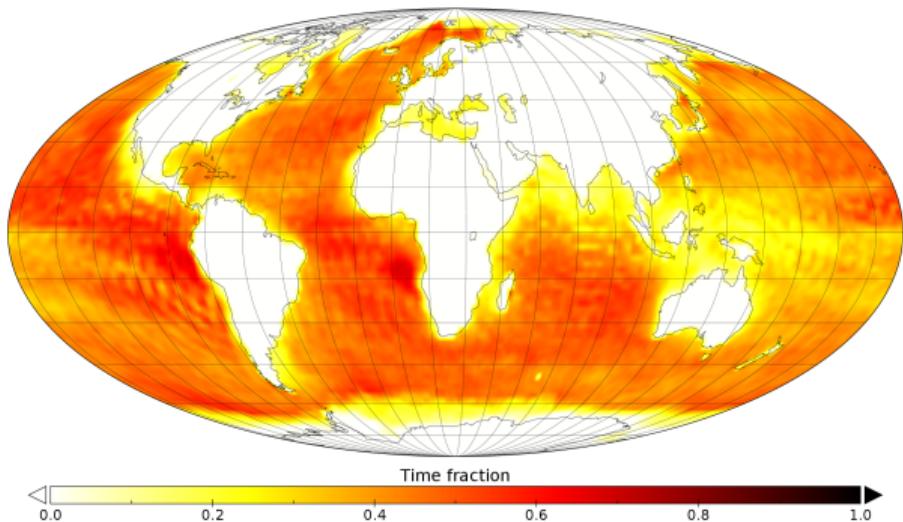
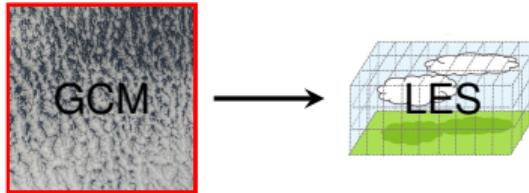


3. Emulator-GCM coupling



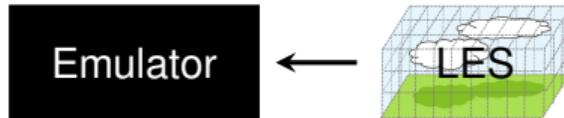
Training simulations

- LESs require initial conditions and forcings ⇒ GCM
- Select GCM columns with marine stratocumuli:
 - Marine
 - No sea ice
 - Low clouds
 - No clouds above low cloud
 - No fog
 - No ice
- Sampling with binary space partitioning



Emulator training

- To train the emulator, LESs are carried out in different conditions
- Four training sets with 1 140 LESs done so far
- Sets differ in day or night and sectional or bulk microphysics
- Total cost approximately 240 000 CPUh, each set takes 3-7 days in real time
- Sectional microphysics increase the cost 17-fold

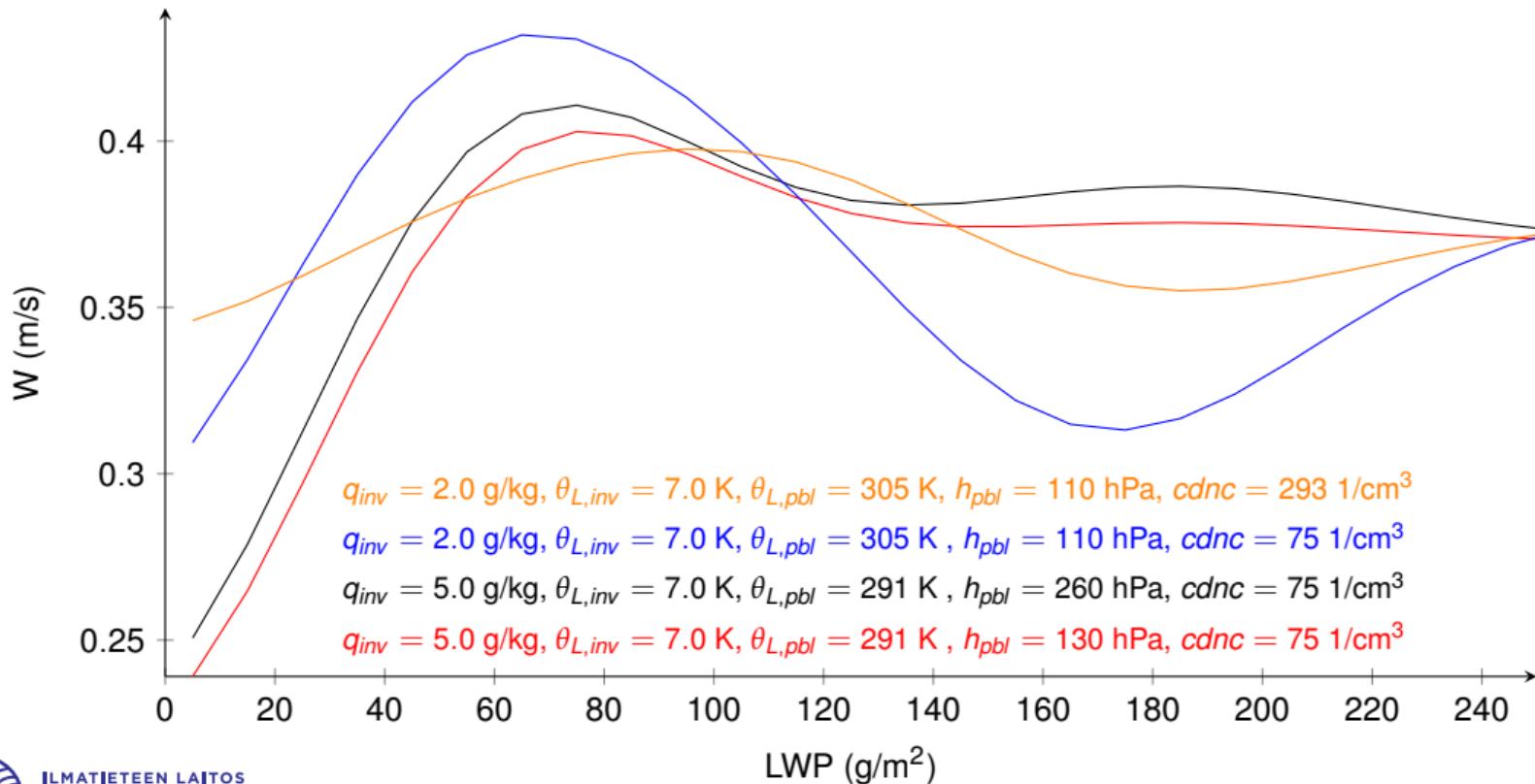


Input variables:

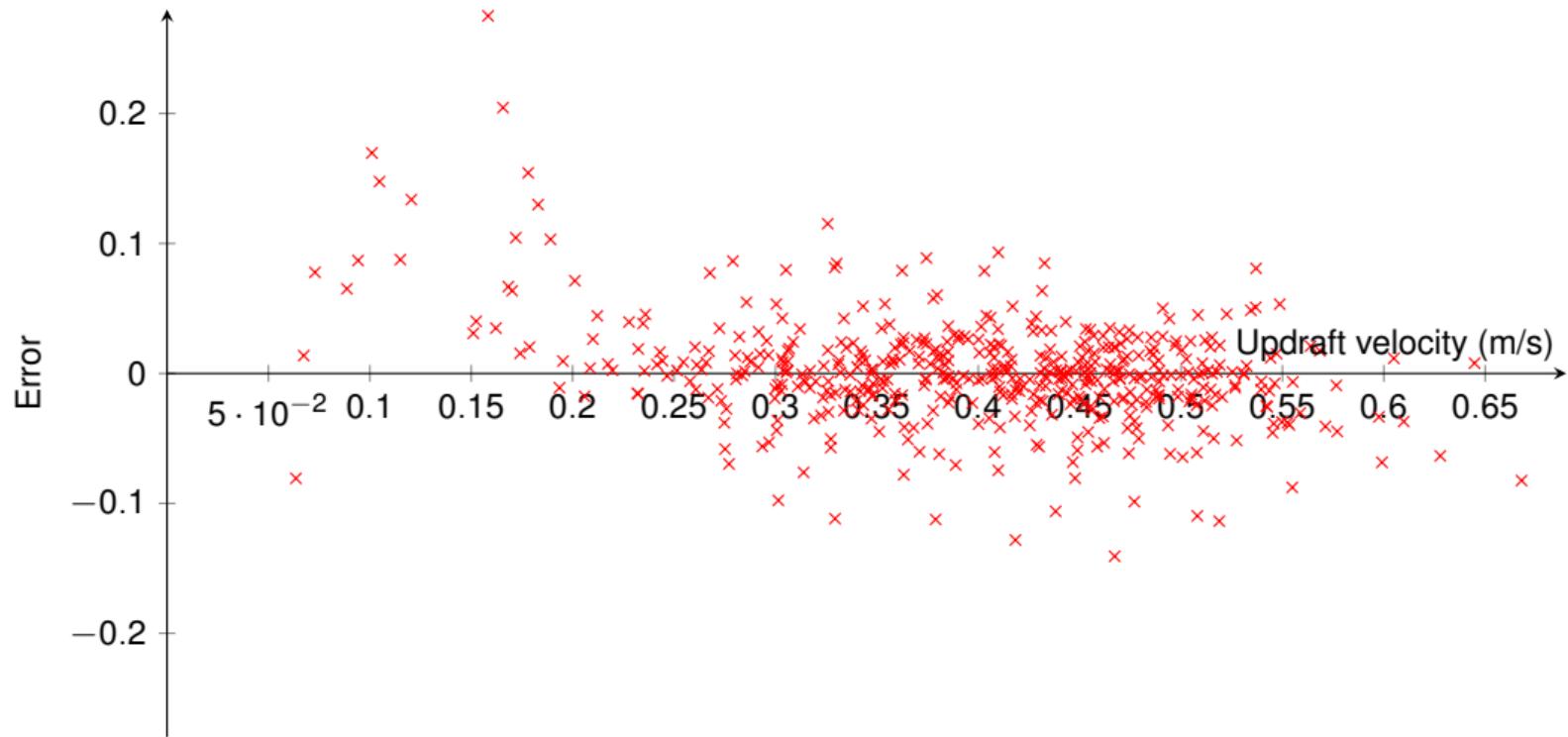
- Inversion strength
- Liquid water potential temperature
- Boundary layer height
- Liquid water path
- Aerosol numbers
- Aerosol dry radius
- CDNC
- Solar zenith angle



Emulated updraft velocity



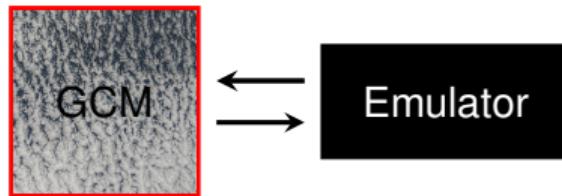
Errors in emulated updraft velocity



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Coupling

- Trained emulator will be coupled to ECHAM-HAM
- Emulator applied only on columns where marine stratocumuli are present
- Coupling work ongoing:
 - Updraft velocity
 - Total rain water production rate
 - ...
- Current work at proof-of-concept stage



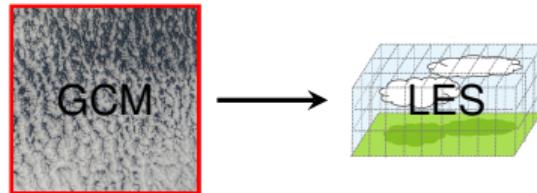
- Validation against conventional parametrisations and satellite data
- EC-Earth implementation later?



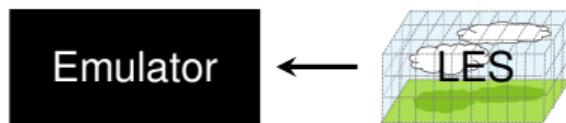
Summary and outlook

- Emulation of subgrid-scale aerosol-cloud interactions in climate models
- Concentrate on marine stratocumuli
- Emulator based on Gaussian processes, coupled to a global climate model
- LES used to generate training data
- Updraft velocity first variable to emulate, more later
- Current work at proof-of-concept stage

1. Training set creation



2. Emulator training



3. Emulator-GCM coupling

