cloud cover parameterisation: options

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ICON cloud community

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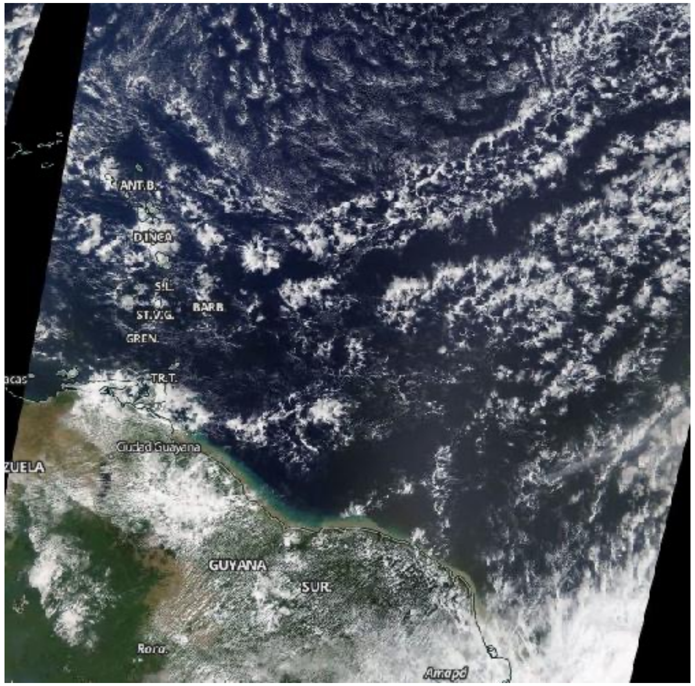
cloud parameterization - outputs

Importance on radiation:

1. cloud cover, q_l, q_i
2. overlap (vertical correlation)
   - exponential in-coud & random between cloud layers
   - decorrelation length scale (function of regime)
3. resolution dependency
   - dx → 0 : sharp q_t PDF, CC=[0,1]
   - dx large: wide q_t PDF, CC∼0.6
   - option no deep or shallow convection parameterisation
4. in-cloud (horizontal) variability of q_l, q_i

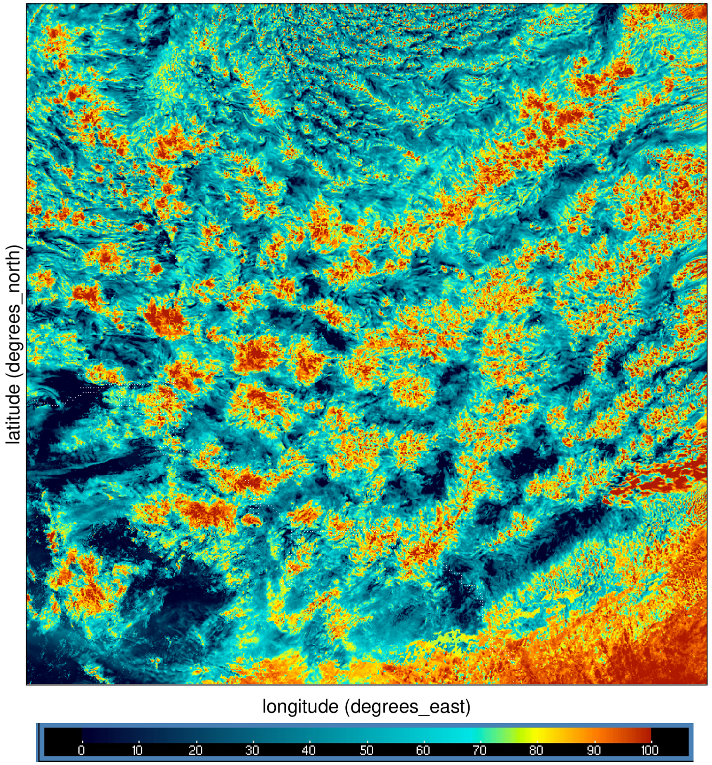
EUREC4a 7.2.2020 NASA Worldview

TERRA



equator overpass:
10:30am

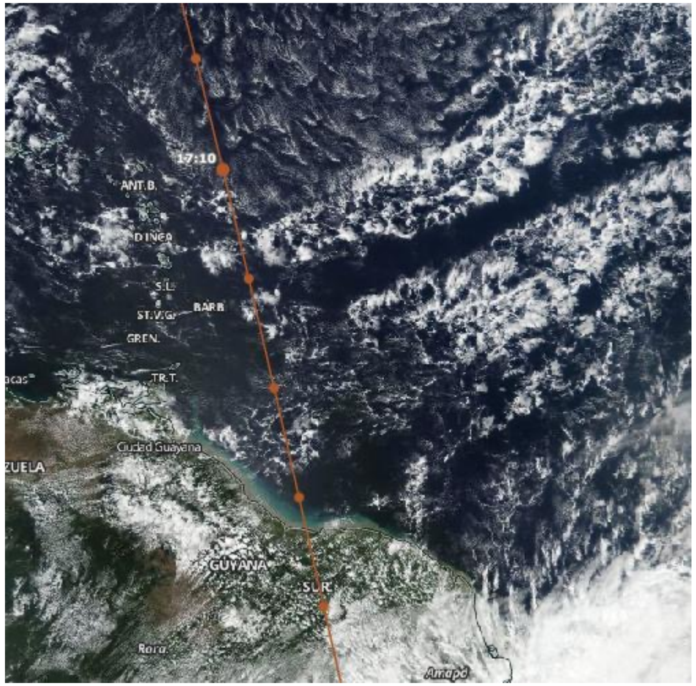
ICON
total cloud cover (%)



12:00am (36h forecast)

ICON at 1.25km

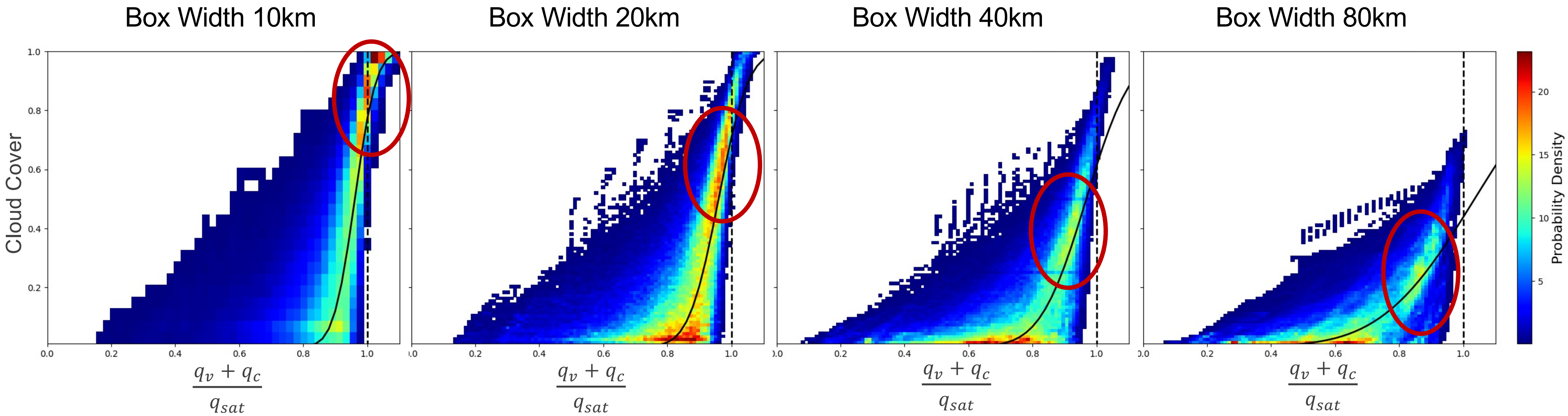
VIIRS



equator overpass:
1:00pm

1º – 23º North
-66º – -44ºEast

PDF ($\frac{q_v+q_c}{q_{sat}}$, cloud cover)   resolution dependence



- coarse grain to 10/20/40/80km
- widening of PDF for lower resolution
- Schemann et al (2013):
  total water power spectrum $P(k) \sim k^{-2}$ for dx = 1000km to 0.1m

Height 2000m

fit to error function

cloud parameterization – verification data

- model data using UCLA-LES, MicroHH, ICON-LEM
- comparison to SCM (ensemble)

- cases:
  - ARM (land shallow cumulus)
  - RICO (ocean shallow cumulus)
  - EUREC4A (ocean shallow cumulus) – 300m Hauke/Daniel
  - DYCOMS or VOCALS (stratocumulus)
  - GoAmazon (tropical land deep convection)
  - FESSTVal (3 composite cases: deep anvil, afternoon cumulus, thin cirrus)

- observations:
  - ISOLDE: radiometer on radiosonde (Lindenberg)
  - satellite: passive SEVIRI (CLARA, MFASIS)
    active CLOUDSAT/CALYPSO
  - in-situ: aircraft (field experiment)

cloud parameterization – options

1. **simplest scheme**: Gaussian with σ_{qt} from turbulence, anvil from convection

2. **higher order** assumed PDF:
   - double Gaussian (Ann-Kristine Naumann, 2013)
   - Beta distribution (Vera Schemann, 2013)
   - skewness from convection or stratocumulus (see below)
   - caveat: requires perfect input (3 moments), e.g. sign of skewness

   options for stratocumulus:
   - bi-modal distribution (Winton van Weverberg, 2020)
   - modified ETS to suppress shallow cumulus (Hideaki Kawai)
   - grid-refinement (Grenier & Bretherton 2002, reconstruction)
   - high vertical resolution (L200-L300, Hsiang-He Lee)

3. **prognostic** CC or σ_{qt} equation (Tiedtke, 1993, Tompkins, 2003)

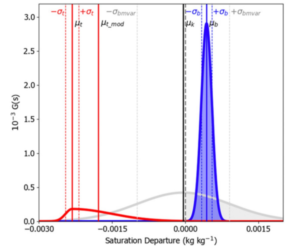
4. **ice phase**: anvil by convective detrainment, cirrus from microphysics)

HIGHTUNE cloud parameterization talks (Apr. 2021)

A physically-based bimodal diagnostic cloud scheme: description and evaluation

Kwinten van Weverberg (Met Office)

- bi-modal diagnostic cloud scheme for regional UM and complement PC2 in global UM
- focus on stratocumulus entrainment zone
    - 1 mode: mixed layer air (moist)
    - 1 mode: air above boundary layer
    - double Gaussian with weights by water conservation



Realities of developing and improving parameterizations related to clouds in global climate models.

Hideaki Kawai (JMA)

- strcu: use modified ETS, turn off sh. cumulus, cloud top entrainment (KH 1993, WB 2006, Kawai 2017)
- SH clouds: Wegener Bergeron Findeisen, increase supercooled water
- improve cloud micro, turb., shallow, cloud overlap, radiation, aerosols, cloud fall speed

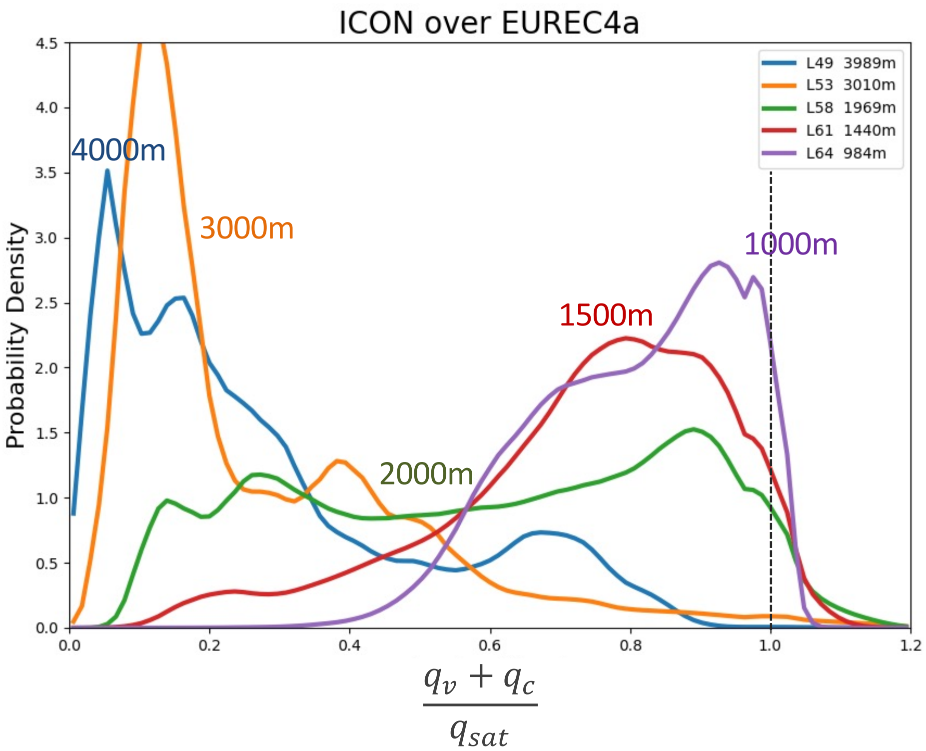
Higher Vertical Resolution for Select Physical Processes in the Energy Exascale Earth System Model (E3SM).

Hsiang-He Lee (LLNL)

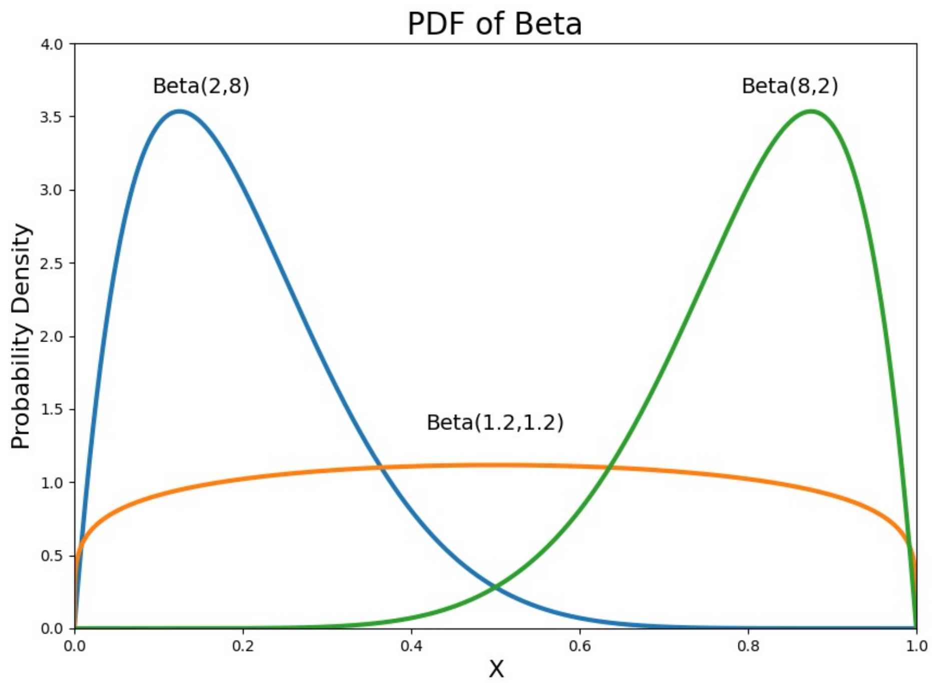
- strcu missing in CLUBB simulations
- 2 vertical grids (physics, dynamics)
- L200 - L300 best for strcu

PDF of total water $\frac{q_v + q_c}{q_{sat}}$

Beta distribution



- cumulus and thin anvil: positive skewness
- low stratiform clouds: negative skewness

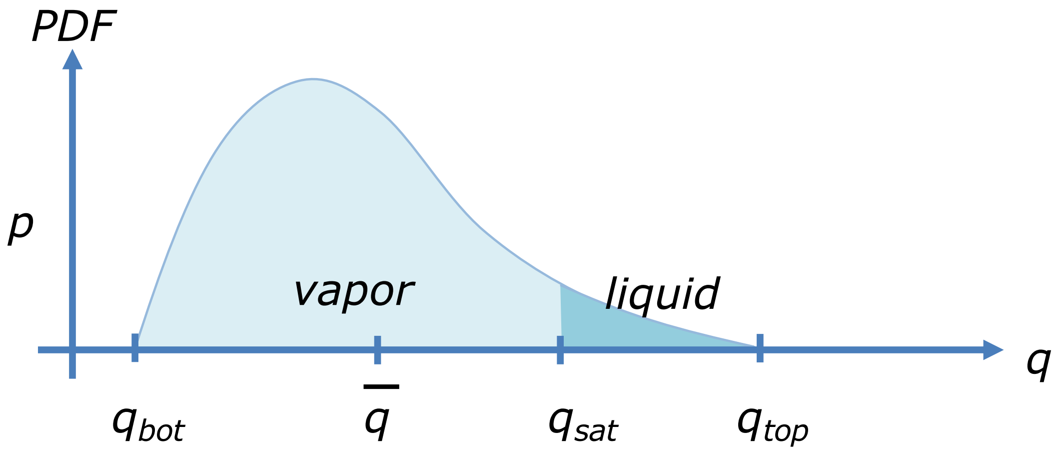


beta distribution: $$G(t) = \frac{1}{B(p,q)} \frac{(t-a)^{p-1}(b-t)^{q-1}}{(b-a)^{p+q-1}} \qquad (a \leq t \leq b)$$

beta function: $$B(p,q) = \frac{\Gamma(p)\Gamma(q)}{\Gamma(p+q)}$$

Adrian Tompkins (2002) and Vera Schemann et al (2013)

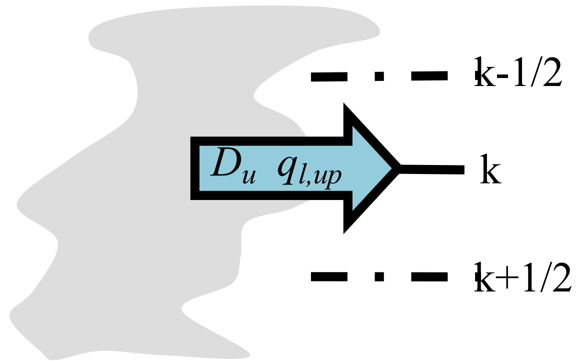
diagnostic ICON cloud cover: conceptual ideas



Beta distribution

Tompkins JAS (2002)

mean:	dynamics
standard deviation:	TKE scheme
skewness:	convection



goals:

- combine cloud with turbulent and convective source terms
- with and without convection parameterisation
- diagnostic, simplified
- resolution dependant
- tunable parameters (empirical or ML)