Modeling (and observing) of entrainment processes

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BNL Entrainment Workshop
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Modeling results
&
Observational proposals

1. Stochastic Parcel Model (SPM)

   SPM should be evaluated observationally

2. Direct measurement using LES

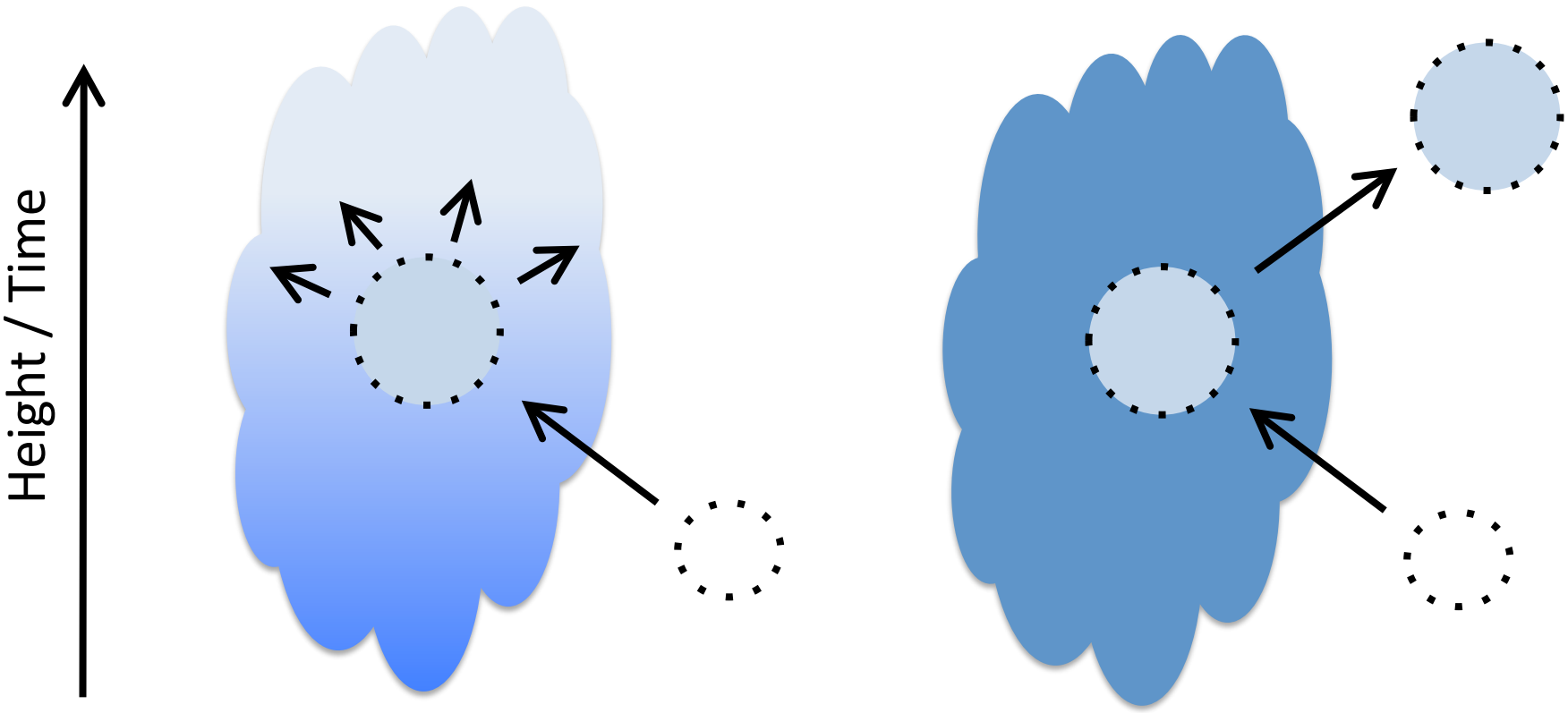
   Direct measurement using observations?

3. 3D stereo imaging of clouds – a proposal

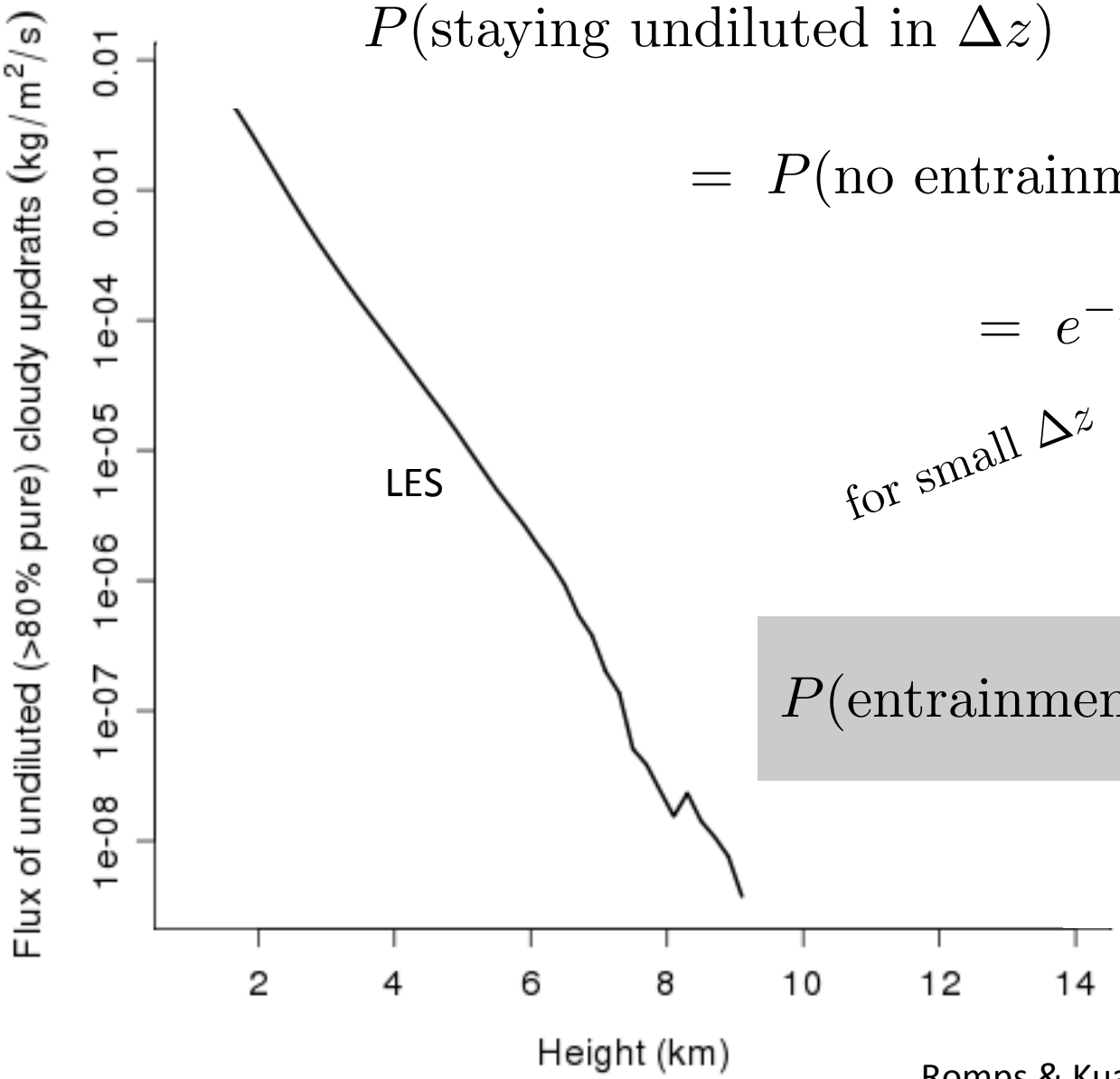
The entrainment rate is overrated.

It is not the fundamental control parameter.

The **<u>same</u>** entrainment rate can give **<u>different</u>** dilutions



LES suggests the Poisson mixing length is more fundamental



$$P(\text{staying undiluted in } \Delta z)$$

$$= P(\text{no entrainment event in } \Delta z)$$

$$= e^{-\Delta z/\lambda}$$

for small Δz

$$= 1 - \frac{\Delta z}{\lambda}$$

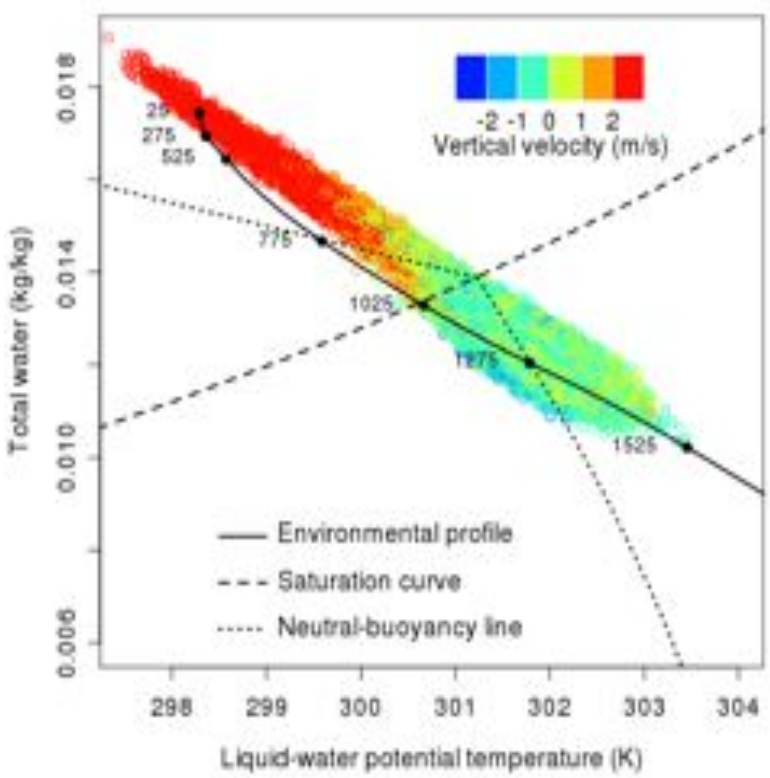
$$P(\text{entrainment event in } dz) = \frac{dz}{\lambda}$$

Romps & Kuang, "Do undiluted plumes...," 2010

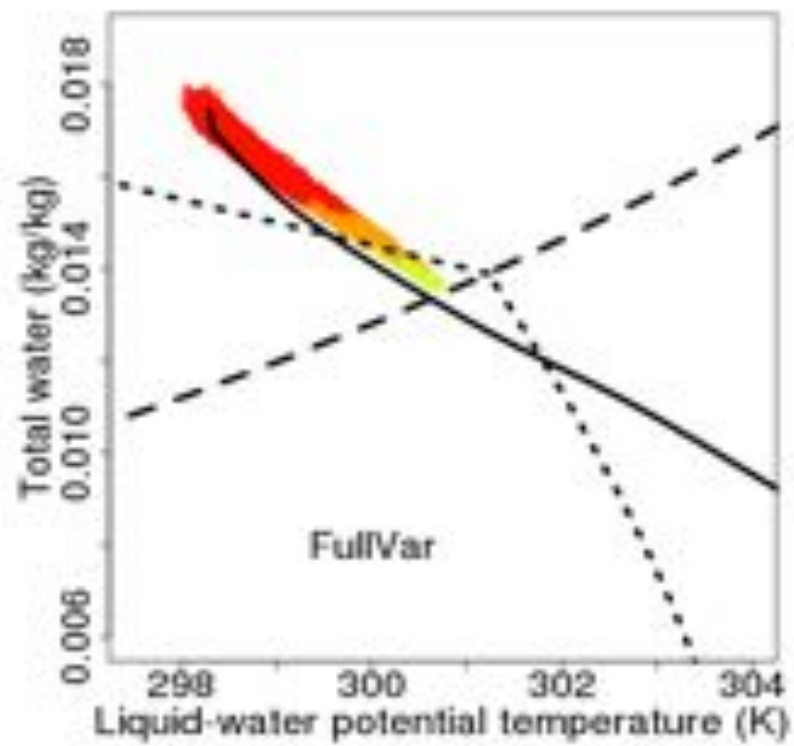
The Stochastic Parcel Model (SPM) based on Poisson entrainment

Comparison of Paluch diagrams at 1275 meters
for trade-wind cumuli

LES



SPM

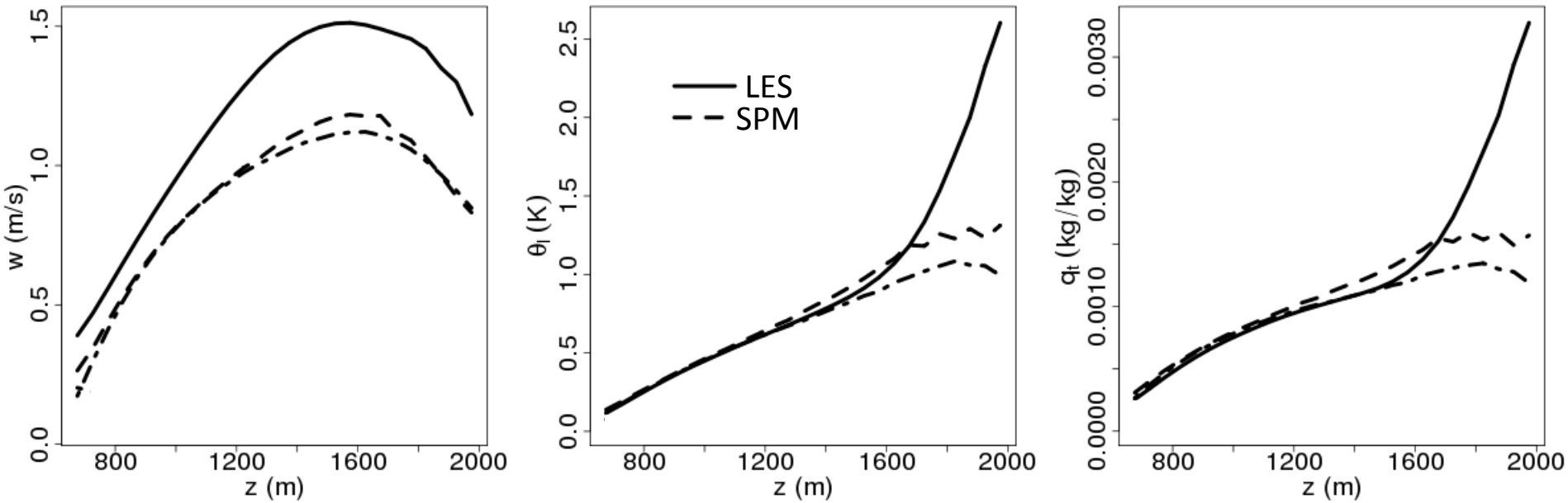


Romps & Kuang, “Nature versus Nurture...,” 2010

The Stochastic Parcel Model (SPM) based on Poisson entrainment

Comparison of heterogeneity as a function of height

Standard deviations



Vertical velocity

Liquid-water potential temperature

Total water

Romps & Kuang, "Nature versus Nurture...," 2010

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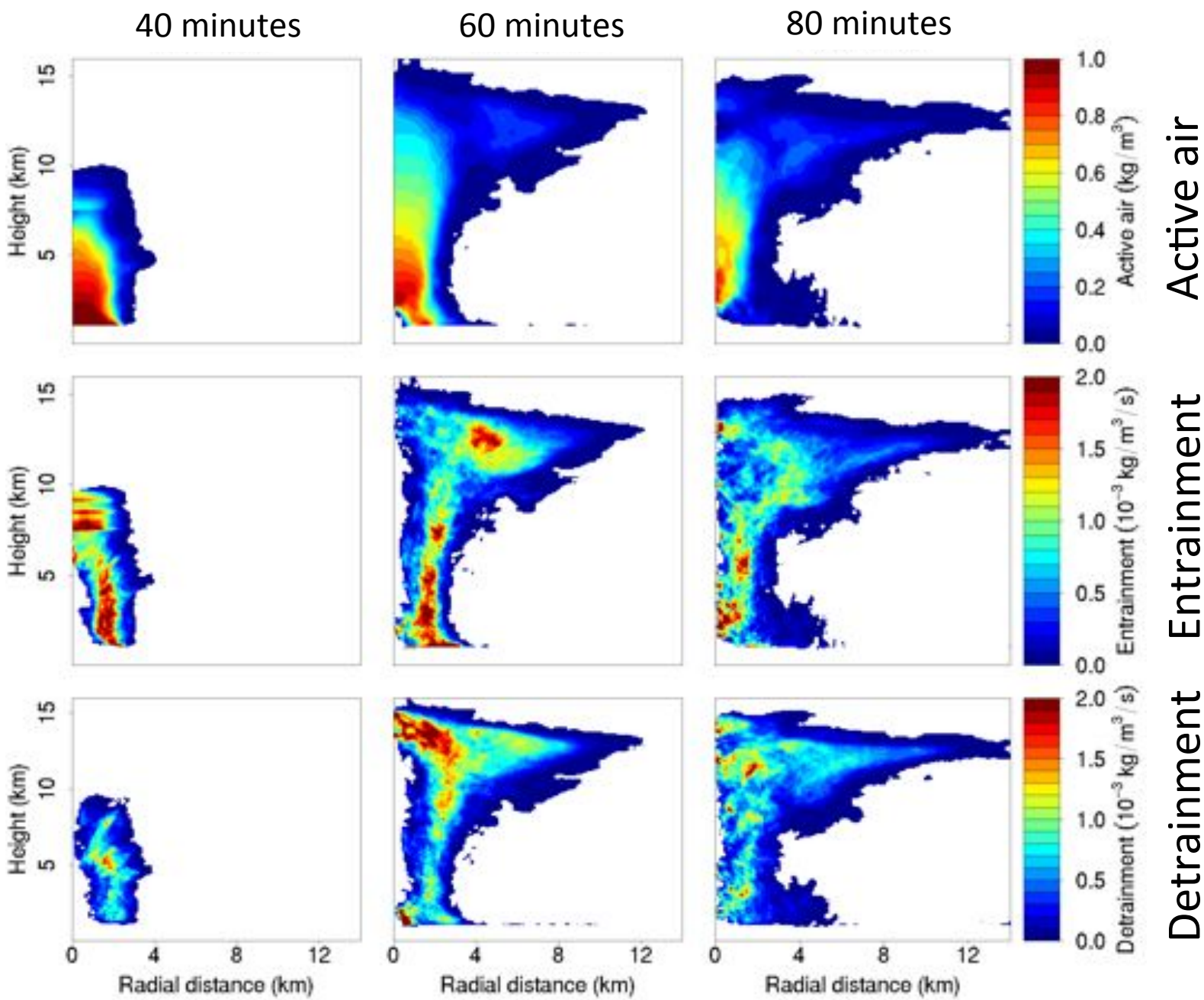
Direct measurement of entrainment

Romps, "A direct measure of entrainment," 2010

Direct measurement of entrainment



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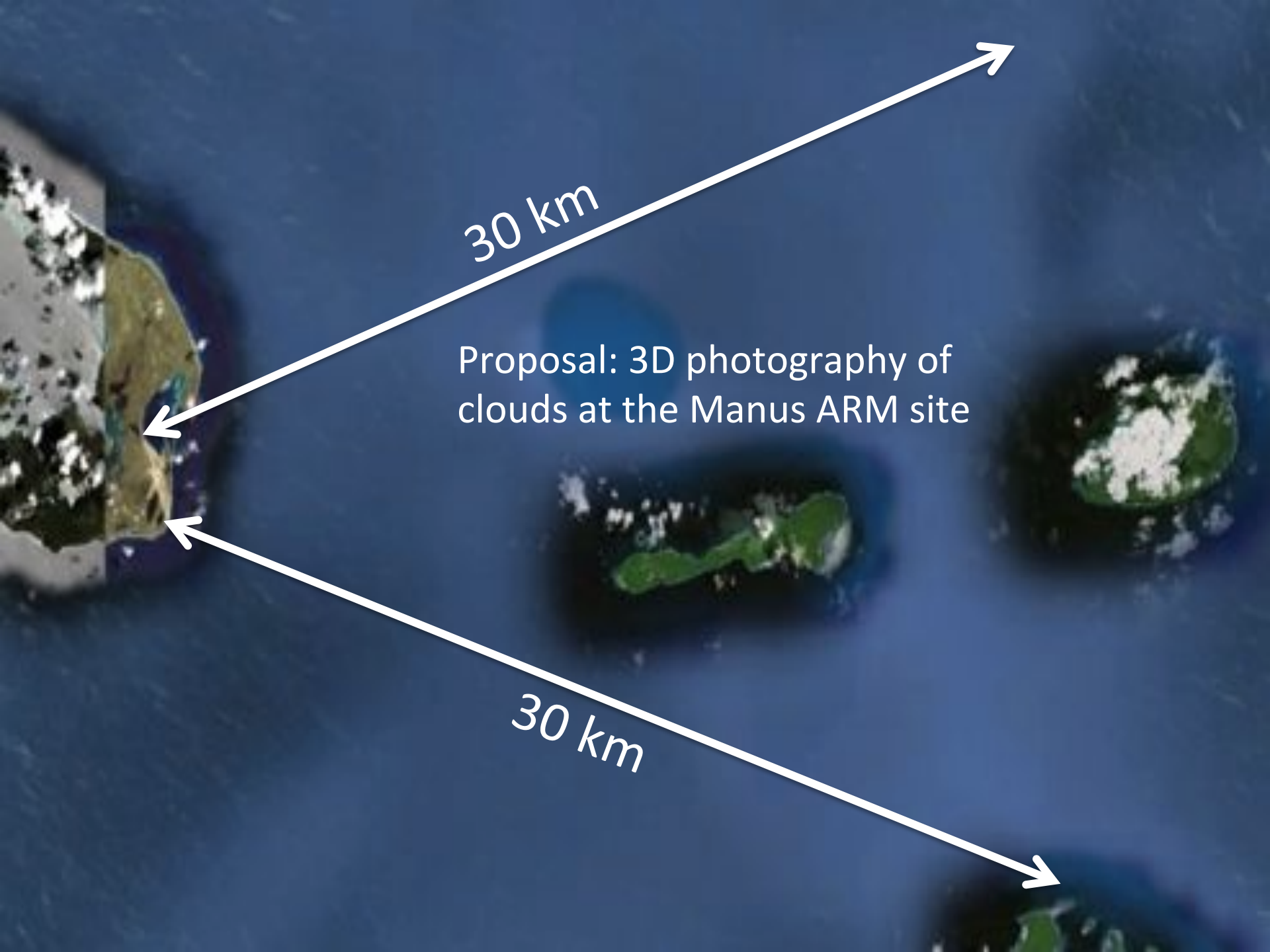
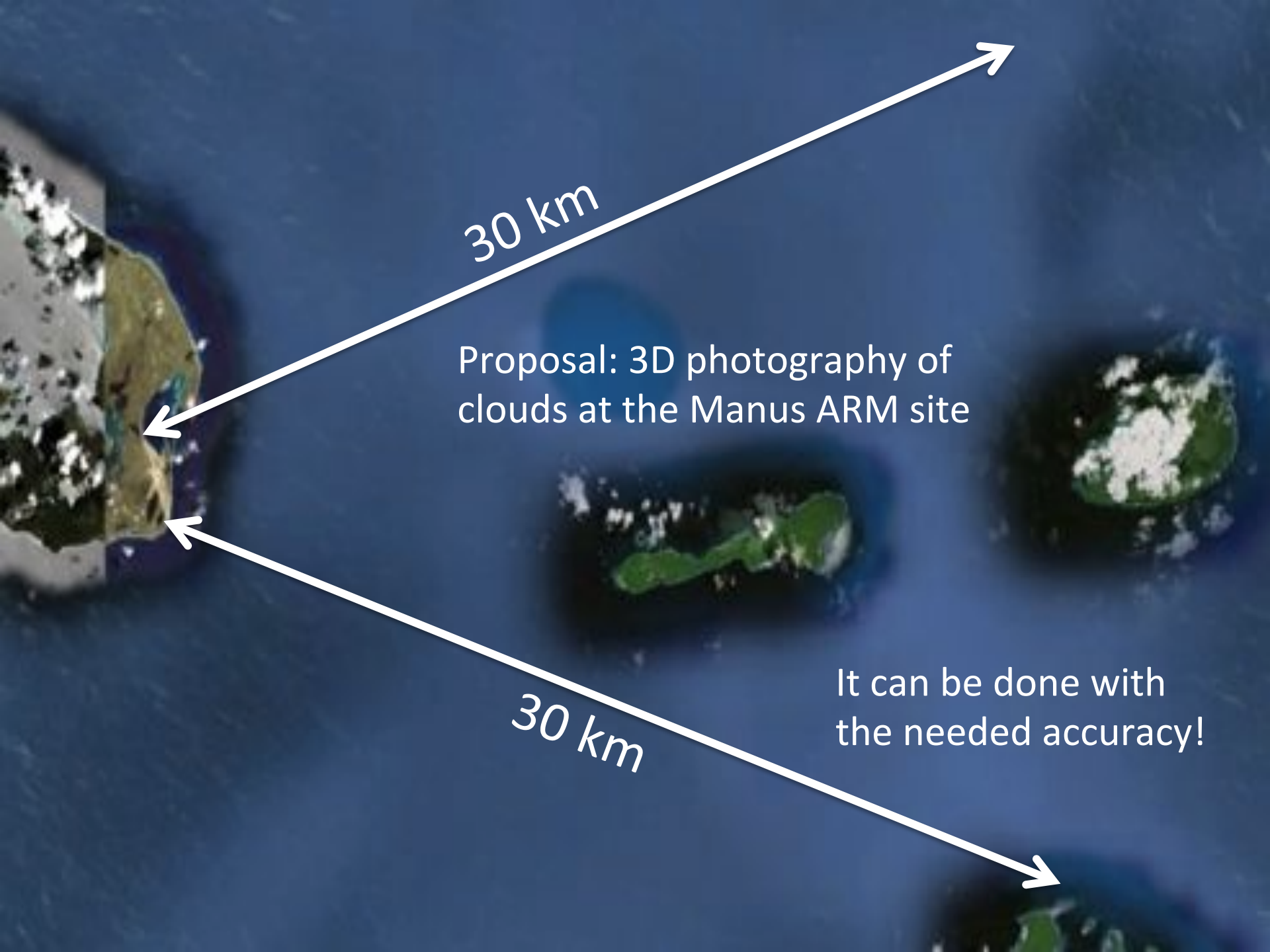
ARM site at Manus Island


30 km
Proposal: 3D photography of clouds at the Manus ARM site
30 km

400 m
Camera 1
Camera 2

13 km
Camera 2
Camera 1
Emeryville breaker
Jetty
Bottom of building
Prediction
Treasure Island pier
Corner of Oakland pier
Image © 2011 TerraMetrics


30 km
Proposal: 3D photography of clouds at the Manus ARM site
30 km
It can be done with the needed accuracy!

Science objectives

Cloud-top vertical velocities (especially for z > 10 km)

Direct measure of entrainment from cloud-surface flow

Size statistics

Mass fluxes

All of these correlated with existing ARM measurements

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