Aerosols, Water & Climate: Current Needs & Future Directions

Fred J. Brechtel
CEO & Owner
Brechtel Mfg. Inc.
www.brechtel.com
fredj@brechtel.com

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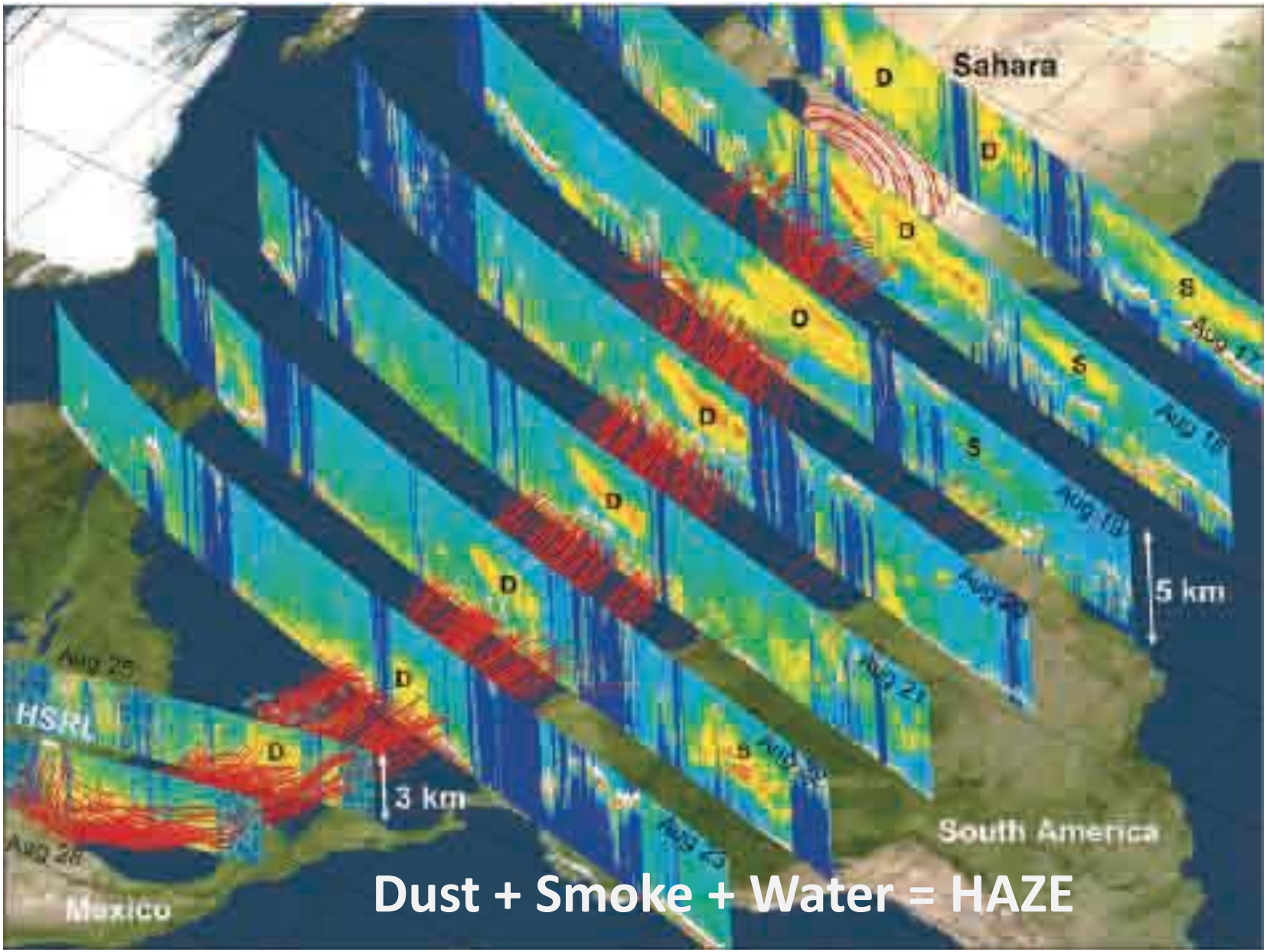
Aerosols + Water = HAZE

Credit: Dr. C. McNaughton, NASA DC-8 over Mexico City 2006


Credit: US Climate Change Science Program Report, NASA 2009
Biomass burning + Water = HAZE



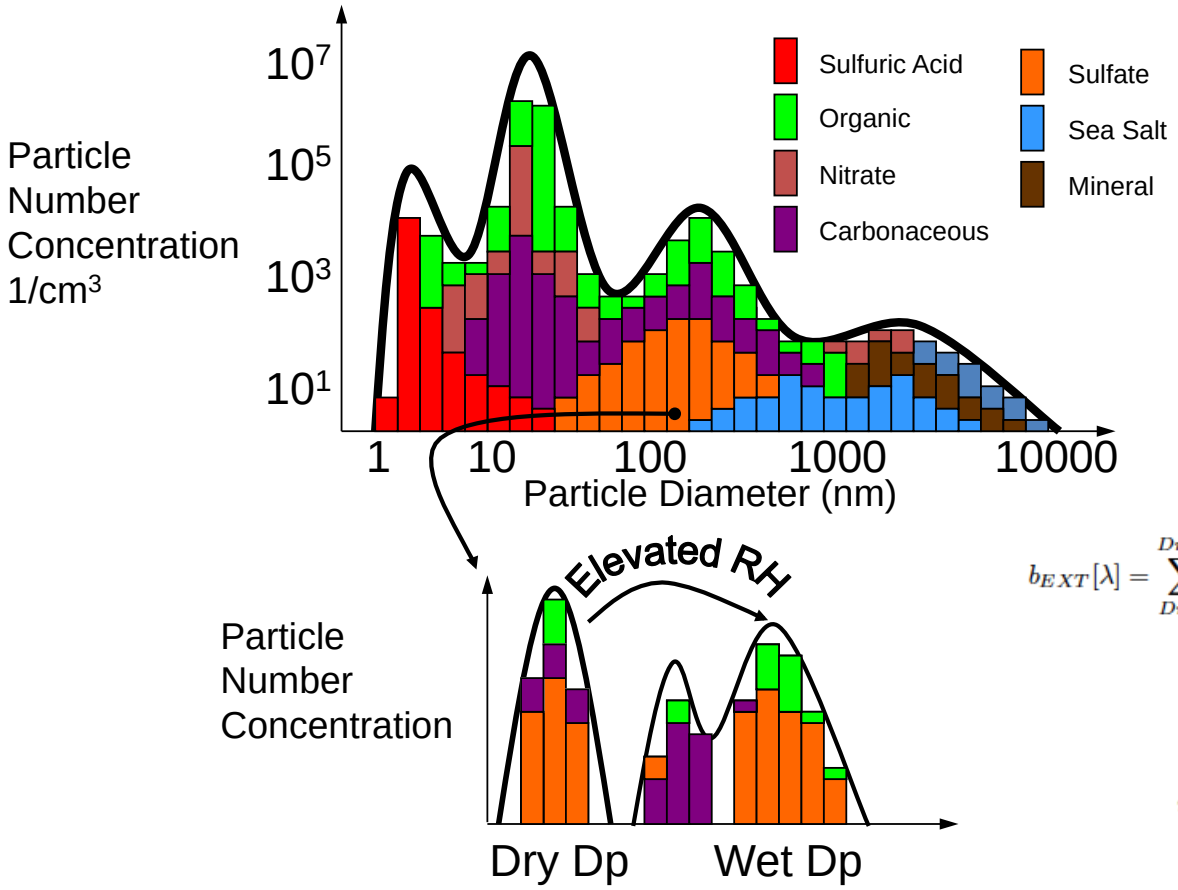
Credit: US Climate Change Science Program Report, NASA 2009

Current Science Needs: Hygroscopicity

Reduce climate change prediction uncertainties in aerosol forcing through sustained measurements

1. Wet optical closure
2. Aerosol-Cloud closure
3. Satellite retrieval validation (long term)
4. Regional ground networks (long term)

Direct Effect: No water
How can we calculate it?



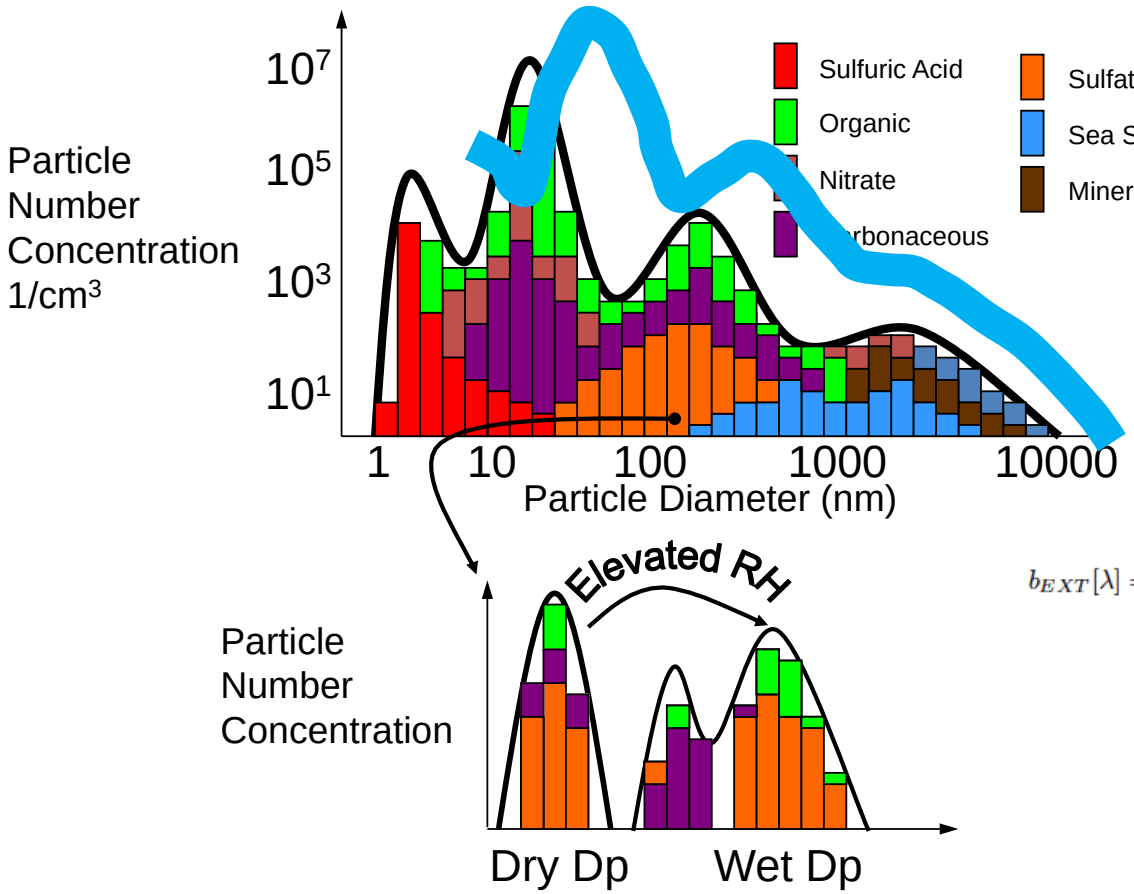
MIE Theory
DDSCAT

$$b_{EXT}[\lambda] = \sum_{Dmin}^{Dmax} \frac{\pi D_p^2}{4} Q_{EXT}(\alpha, n) \frac{dN}{dlogDp} dlogDp$$

$$\alpha = \frac{2\pi Dp}{\lambda}$$

$$n = f(Dp, Chemistry)$$

Direct Effect: Now WITH water
How can we calculate it?



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1. Number Size Distribution
2. Refractive index (λ)
3. Particle extinction efficiency

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Direct Effect: Now WITH water

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$$\alpha = \frac{2\pi Dp}{\lambda}$$

$$n = f(Dp, Chemistry)$$

1. Number Size Distribution
2. Size-dependent water uptake
3. Mass absorption efficiency
4. Mass scattering efficiency

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Direct Effect: Now WITH water
How can we measure it?

1. 'Wet'/Ambient RH Mobility + OPC size distributions
2. Dry Mobility + OPC size distributions
3. HTDMA Size-dependent water uptake
4. 'Wet/Dry' OPC behind Mobility spectrometer
5. Size-dependent chemistry: cascade impactor, mass spec, **new?**
6. 'Wet' nephelometer, size-dependent absorption
7. Light, small, cost-effective devices for unmanned aerial vehicles: Humidified mini-SEMS

'WET' Measurements at the ground and aloft.

Continuously

Focused within satellite 'columns'

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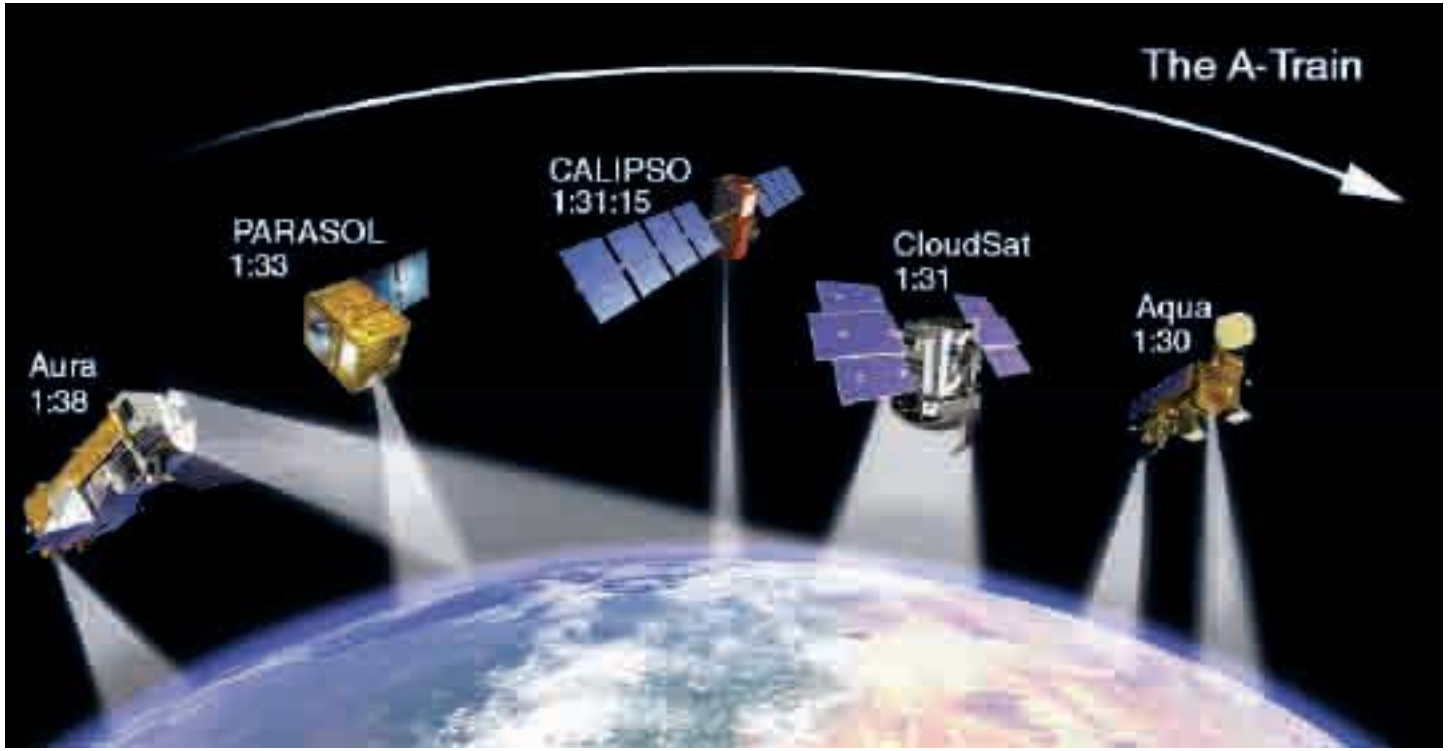
Indirect Effect
Satellites: the Global Context



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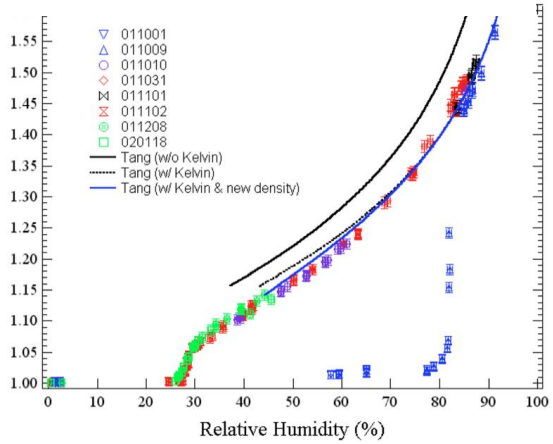
Indirect Effect: Aerosol-Cloud Closure How can we calculate it?

$$S(D) = a_w exp\left[\frac{4\sigma_{drop}\nu_l}{RTD}\right] \Rightarrow S(D) = \frac{D^3 - D_d^3}{D^3 - D_d^3(1-\kappa)} \exp\left(\frac{4\sigma_{s/a}M_w}{RT\rho_w D}\right)$$

$$a_w = exp\left[\frac{-M_w\nu\Phi m}{1000}\right]$$



RH or S(D)

Measure S(D) and D for a given D_d

Fit S(D) eqn to data: derive κ

Derive CCN spectrum from dN/dlogD

Derive Cloud Drop Distribution

Bonus: Wet & Dry Optical closure too

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Indirect Effect: Aerosol-Cloud Closure How can we measure it?

1. Scanning Mobility & OPC Dry & Wet Number Size Distributions
2. Humidified TDMA size-dependent water uptake
3. Cloud condensation nucleus/drop spectrum from UAVs
4. CVI inlet on-board UAV/Ground CVI inlet system
5. Light, small, cost-effective devices for UAVs

GOAL: Predict cloud drop activation
Measurements at the ground and aloft.
Continuously
Focused within satellite 'columns'

Big Problem: a lot of complicated simultaneous measurements

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Indirect Effect: Aerosol-Cloud Closure How can we measure it?

1. Scanning Mobility & OPC Dry & Wet Number Size Distributions
2. Humidified TDMA size-dependent water uptake
3. Cloud condensation nucleus/drop spectrum from UAVs
4. CVI inlet on-board UAV/Ground CVI inlet system for mtn sites
5. Light, small, cost-effective devices for UAVs

GOAL: Predict cloud drop activation
Measurements at the ground and aloft.
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Other Applications:
Precipitation
Air Quality
Visibility

Big Problem: a lot of complicated simultaneous measurements

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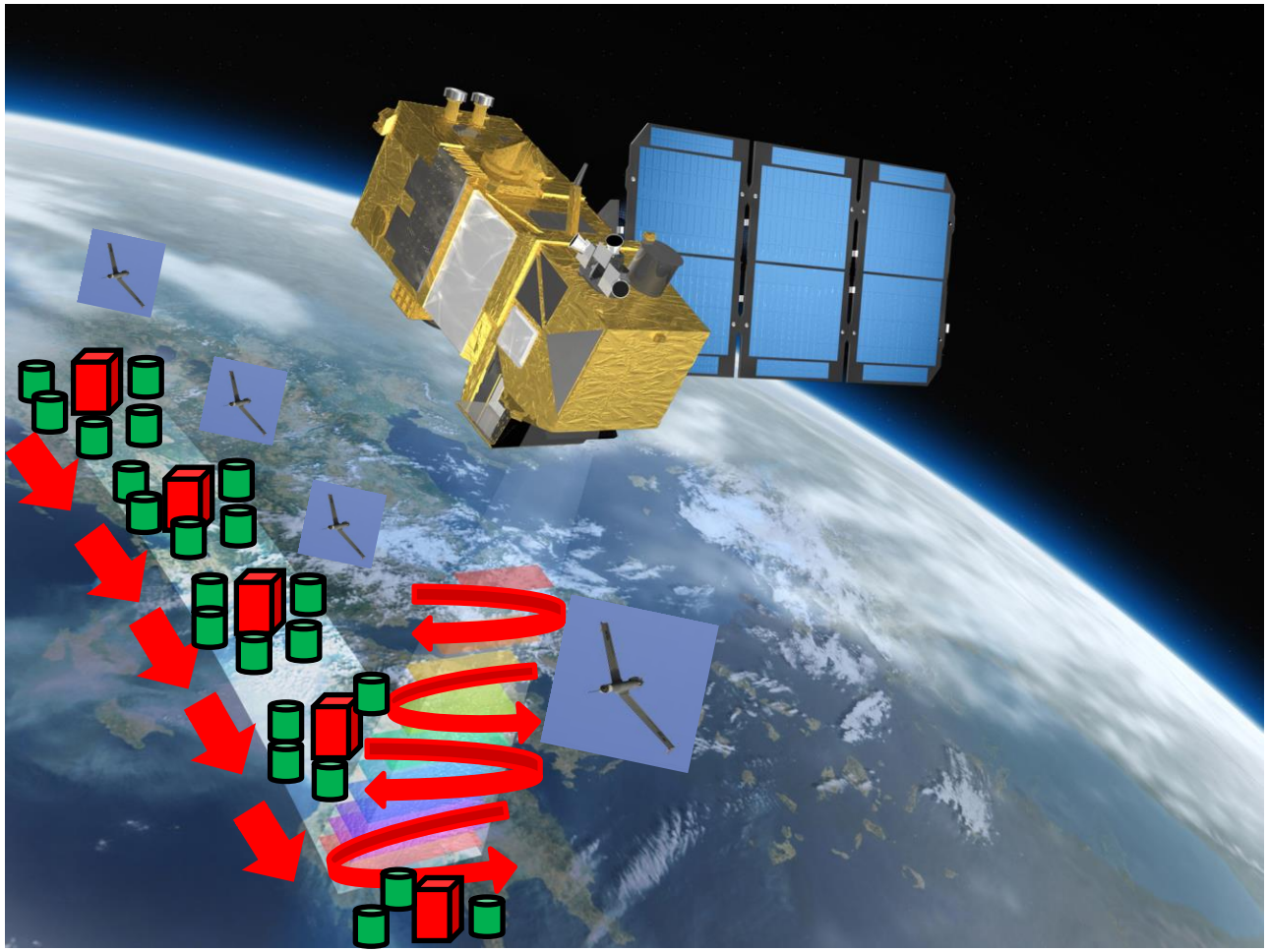
Satellites: In-situ Validation
Future sampling strategies



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Conclusions: Future Directions

We need to do a better job:

- Connecting aerosol to cloud properties: clear questions
- Committing to long-term measurements
- Constraining remote sensing retrievals
- Developing portable, cost-effective instruments
- Collaborating across disciplines and countries

<u>Our children and future generations are counting on us.</u>

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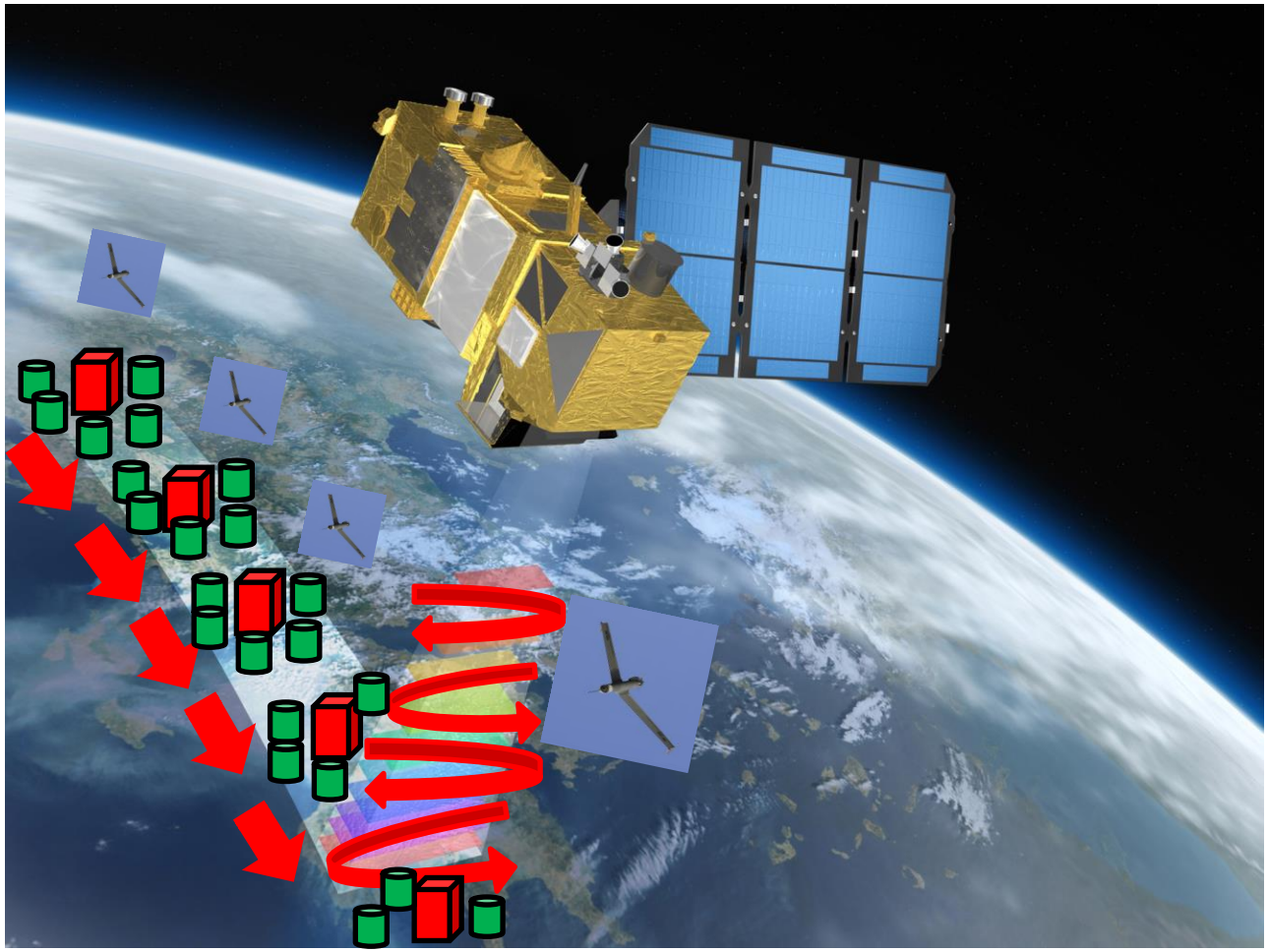
Is this the future?



Thank you for your attention.

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