Notes for new particle formation

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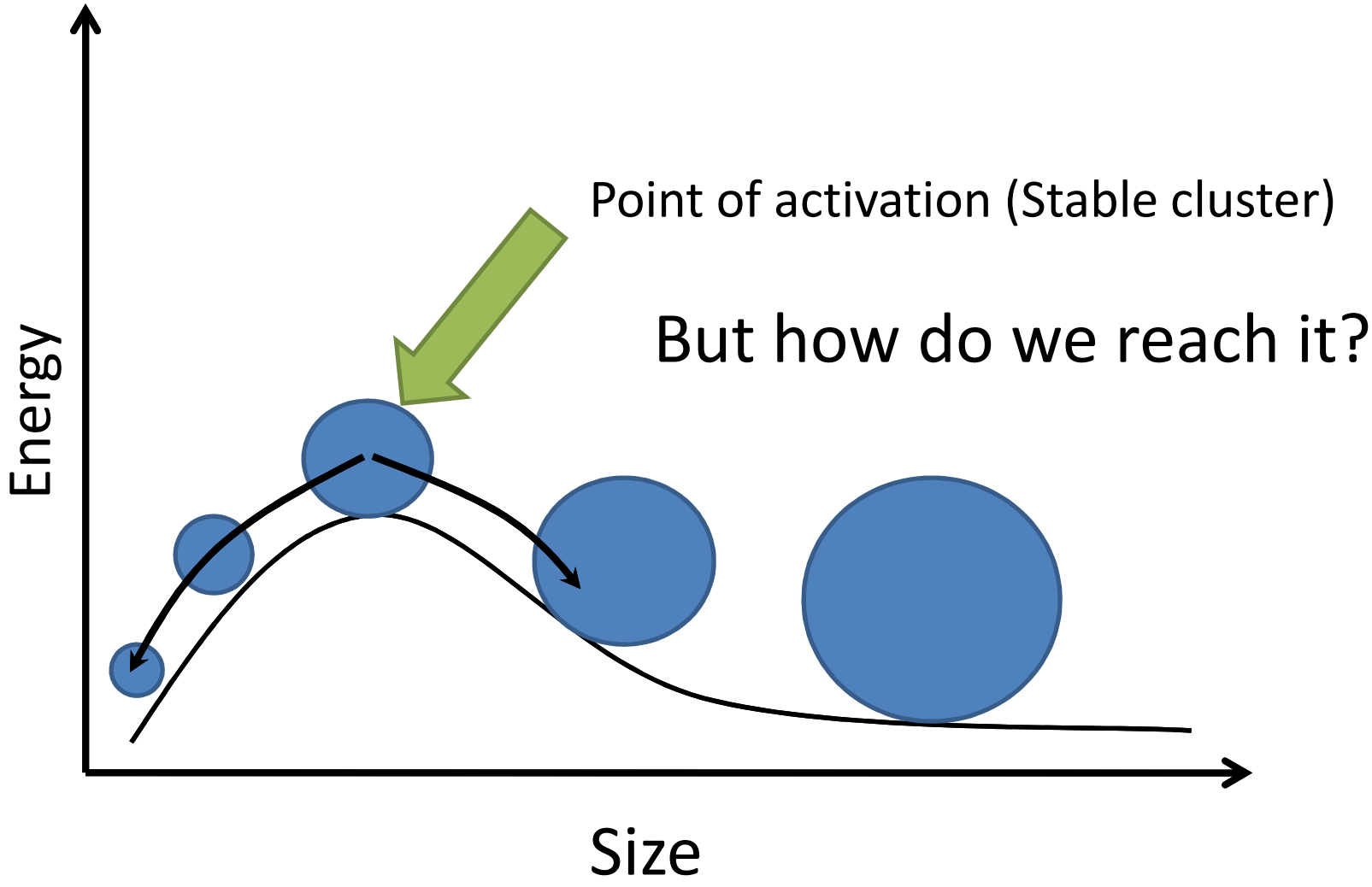
Activation


Point of activation (Stable cluster)
But how do we reach it?
Energy
Size

Why put effort to nucleation

- Get the CCN concentrations correct. Aerosol-cloud interactions pose a large uncertainty in future climate predictions.
- Nucleation and new particle formation contribute to the concentrations of potential CCN's
- Probably large effect in remote areas lacking major primary sources
- Chemical composition crucial. We need to know what makes the particle grow

Available nucleation theories

- Binary
- Ternary
- Kinetic
- Ion-induced
- Activation
- (Organics)

Binary nucleation

H_2SO_4-H_2O

Based on thermodynamical assumption

- Where does it work
  - Upper tropsphere (favoured by low temperatures and high RH)
  - May contribute to nucleation in highly polluted environments (lots of H_2SO_4
- Does not work
  - In lower troposphere (cannot explain nucleation events in remote areas)

Ternary nucleation

H_2O-H_2SO_4-NH_3

Based on thermodynamical assumptions

- Where does it work
  - Some locations it seems to work, but generally overestimates the particle production
- Does not work
  - Always works too well...too high numbers produced

Kinetic limited nucleation

H_2SO_4- H_2SO_4

Based on kinetical assumptions, or simply limited by the maximum number of collisions between two sulfuric acid molecules.

- Where does it work
  - Works pretty well every where (includes free parameter which could include dependence on several different parameters)
- Does not work
  - Does not work all the time
  - Do not know the thermodynamics behind the theory

Ion-Induced nucleation

HSO_4^- -x (H_2O)

Charged ions lower the energy barrier for formation of initial clusters

- Where does it work
  - Works everywhere, but is limited by the amount of ions that can be produced. Can at best explain fractions of observed particle production. It is considered important, since it can give substantial contribution in the beginning of the nucleation. Could be important in the free troposphere and clean and cold environments.
- Does not work
  - It is not sufficient to explain the observed production of new particles. Limited by the number of ions that can be produced.

Conclusions so far:

Many different nucleation theories available, but not applicable to all locations

Some seems suitable for polluted areas, some for remote areas, some for the free troposphere

BUT:

Are we looking for single theory, or do we need a combination of several

All different processes capable of producing particles at some locations

Atmospheric new particle formation

- Nucleation and formation are conceptually different
  - Gap in size between nucleation and observed formation in atmosphere
- Formation occurs everywhere, except in the tropics: Why?
- The growth rates 0.1-20nm globally
  - Depends on latitude, season, height, degree of anthropogenic influence
- Organics play an important role, but occasionally the growth may be explained by condensation of sulfuric acid alone. Requires high levels of pollution.
- HTMA-measurements. Less inorganic, soluble material in smaller particle. Likely dominated by organics (but measurements start only from 10 nm).

Instruments

- Formation rate at a certain size (J3, J10)
  - SMPS/DMPS (J3)
  - CPCBattery (J2, total rate)
  - AIS, BSMA (ion clusters)
- Composition in growing particles:
  - Direct (TDCIMS)
  - Indirect (PTRMS, HTDMA, Volatility)

Future needs

- More field measurements
- Better lab measurements
- Improve representation of mechanisms
- Apply mechanism(s) to box/regional/global models

Field Measurements

- More long term measurements
  - Different environments
  - Global coverage
  - Basic instruments + full suite
- Instrument inter-comparison workshops
- Instrument development + field deployment

Lab Experiments

- Nucleation rates of more complex mixtures
- Vapor pressures of high-molecular weight organics
- Chamber experiments
  - Nucleation mechanisms
  - Compounds responsible for growth (organics)
  - Atmospherically relevant conditions
  - Instrumentation particualry suited for sub-20 nm particles

Model Development

- Improve representation of mechanisms
- Apply mechanism(s) to box/regional/global models and check against observations at larger particle size

Thank you