The air up there

Measurements in Atmospheric Science

E80 Spring 2012

age credit: http://vterrain.org/Atmosphere/

Concepts in Atmospheric Science

- Atmospheric science across the disciplines
- The basics
- Why atmospheric measurements?
- Platforms for atmospheric measurements
- What you might consider for your rocket

Atmospheric Science across the disciplines

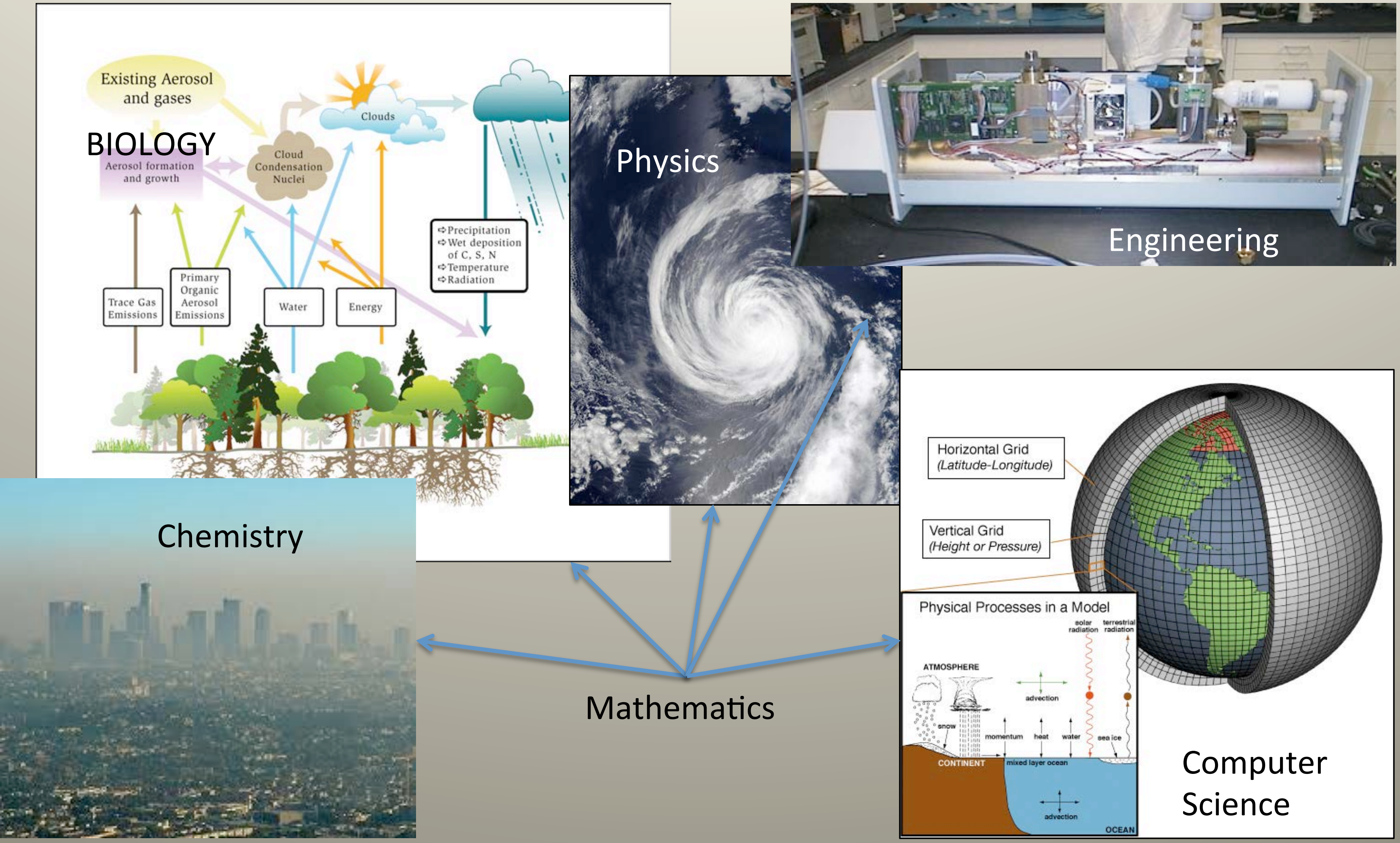


Image credits: atmos.washington.edu, acd.ucar.edu, caice.ucsd.edu, oar.noaa.gov, chemwiki.ucdavis.edu

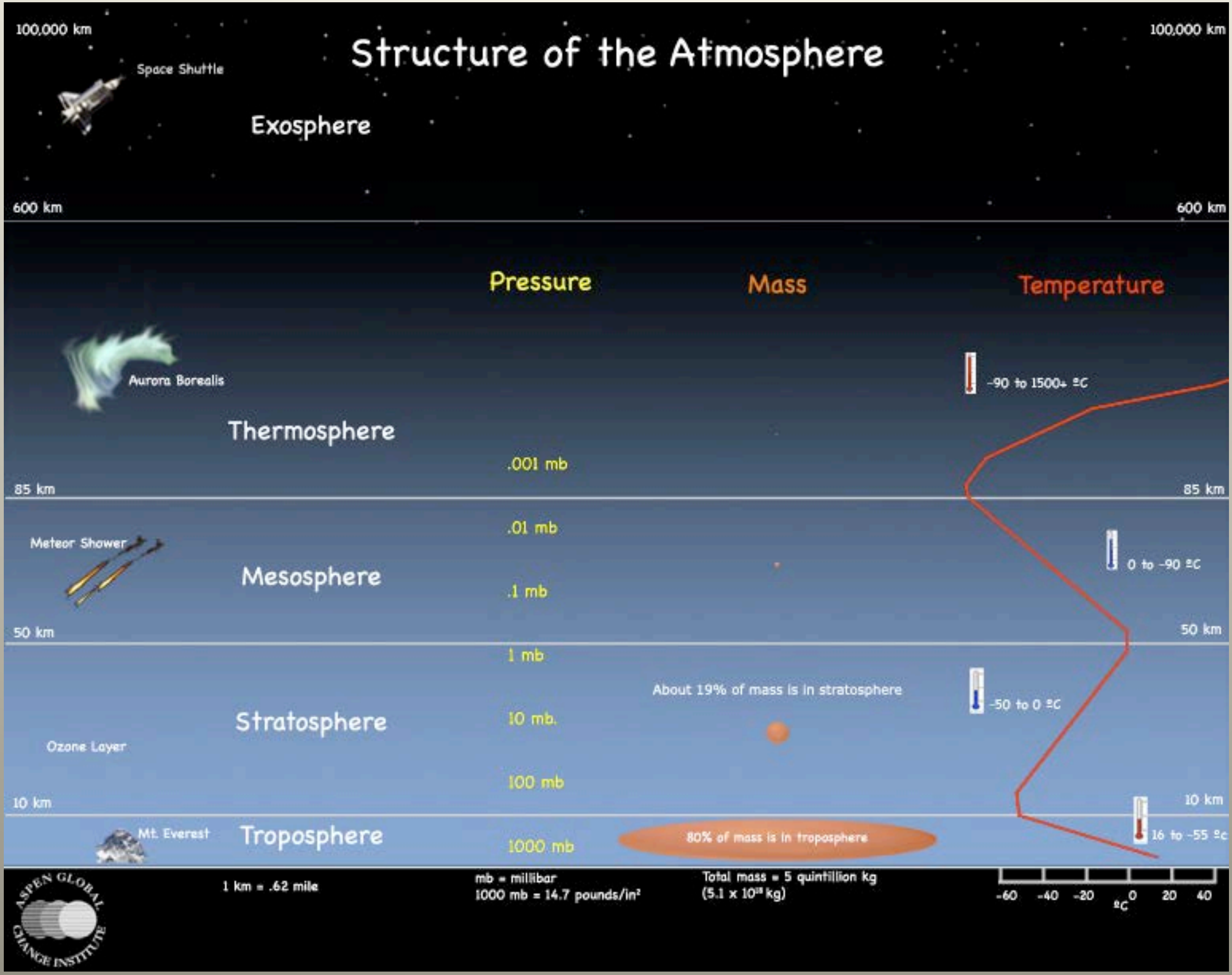


Image credit: agci.org

PBL vs the free troposphere

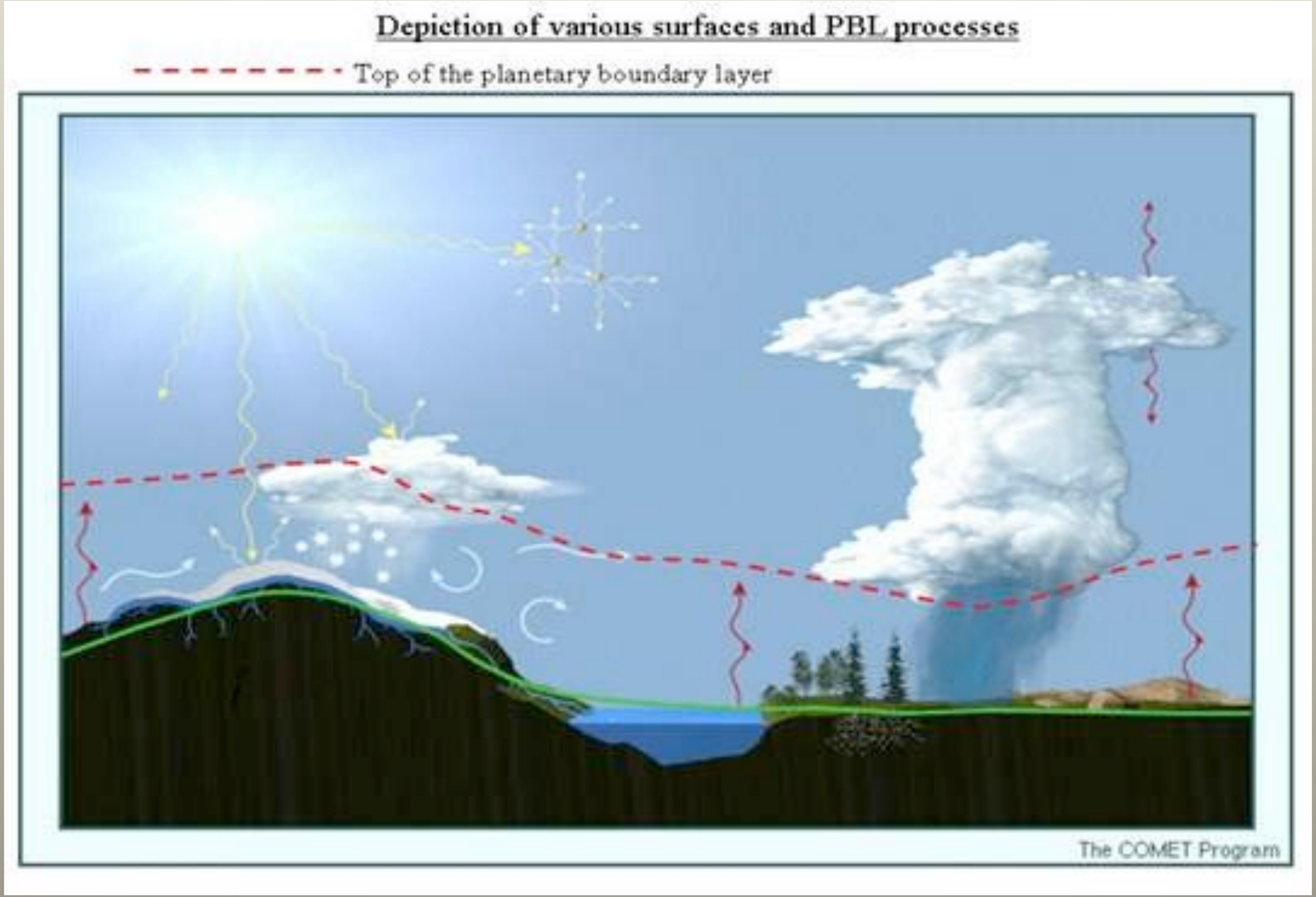
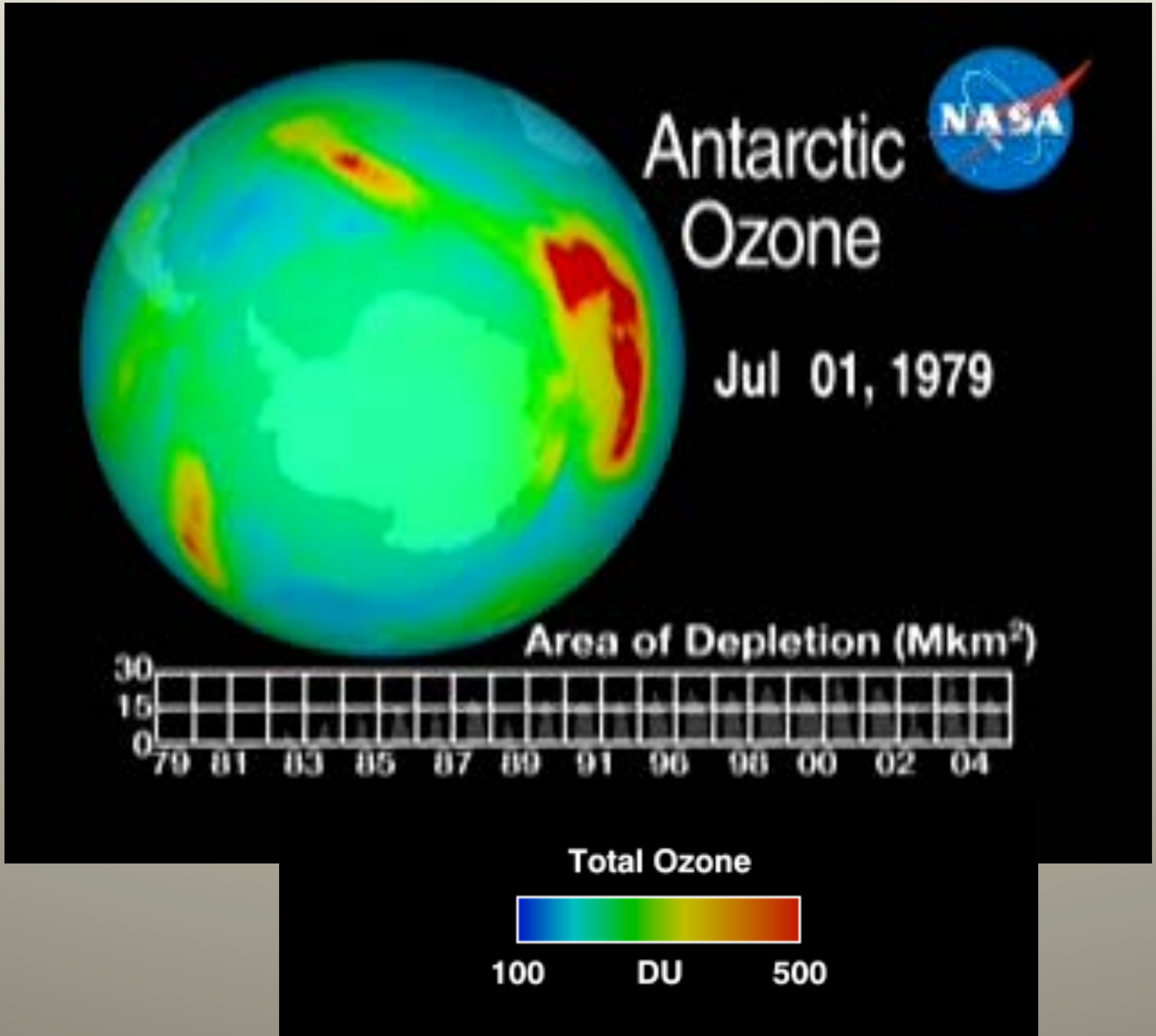


Image credit: esrl.noaa.gov

What's going on in the troposphere?

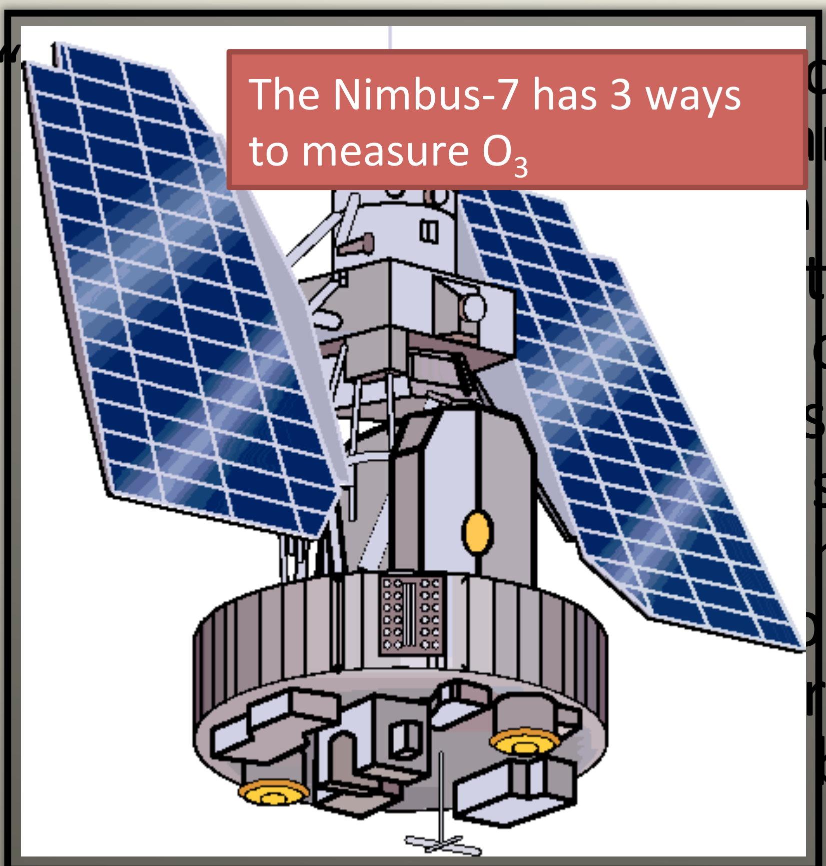
- Nearly all weather (clouds, rain, tornados, hurricanes, snow)
- Nearly all anthropogenic (human-caused) pollution
- Nearly all transport of anthropogenic and natural chemicals (think dust storms, wildfires)
- Warfare related emissions (weaponized aerosols)
- Most of the molecules relevant to climate change (because most of the mass is here).

However....



Antarctic
Ozone
Jul 01, 1979
Area of Depletion (Mkm²)
30
15
0
79 81 83 85 87 89 91 96 98 00 02 04
Total Ozone
100
DU
500

Outliers: How NASA "missed" the ozone hole

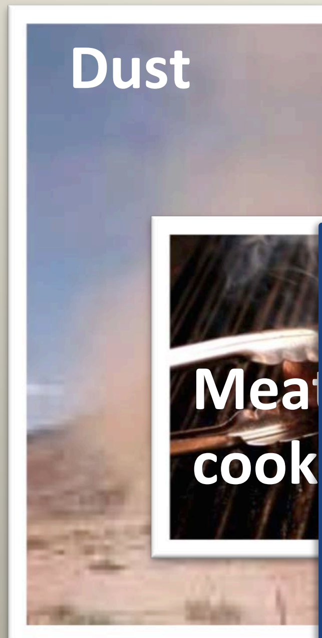


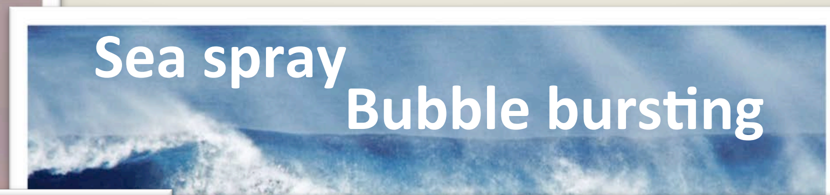
"... ozone that was lower than
... n had ever been reliably
... 1984, *before publication of*
... ticed a sudden increase in
... of 1983. We had decided that
... submitted a paper to the
... summer when Joe's paper
... me thing. As the first one in
... r discovery of the ozone
... ry to talk about how NASA
... but it isn't quite true."

Practical uses for atmospheric measurements

- Air quality control and monitoring (including airborne pathogens)
- Better prediction of tornadoes and hurricanes (improve early warning)
- Changes in patterns (rain, storm tracks) due to changing climate
- Monitoring greenhouse gases and short-lived climate forcers.
- Cross border pollution issues

Introduction to Atmospheric Aerosols:
Particle Sources

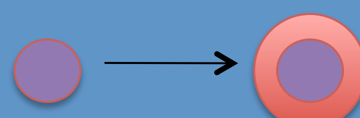


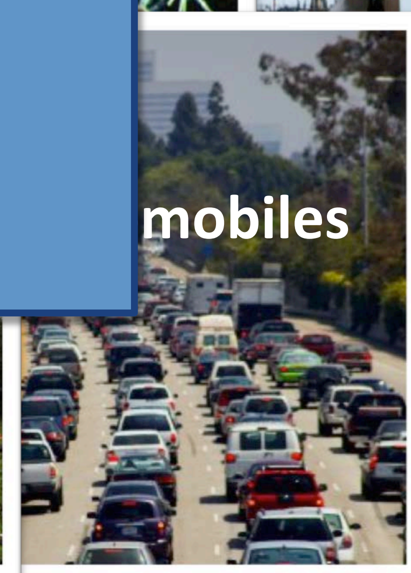


Primary particles are <u>emitted as liquids or solids</u> to the atmosphere.

Secondary particles are <u>emitted as gas phase</u> components and later condense to form particles.

Primary particles that are transported in the atmosphere can <u>accumulate mass</u> from secondary components.





Introduction to Atmospheric Aerosols:
Organic Components are Substantial

Submicron particle composition from an aerosol mass spectrometer:
organic and inorganic (**sulfate**, **nitrate**, and **ammonium**) components

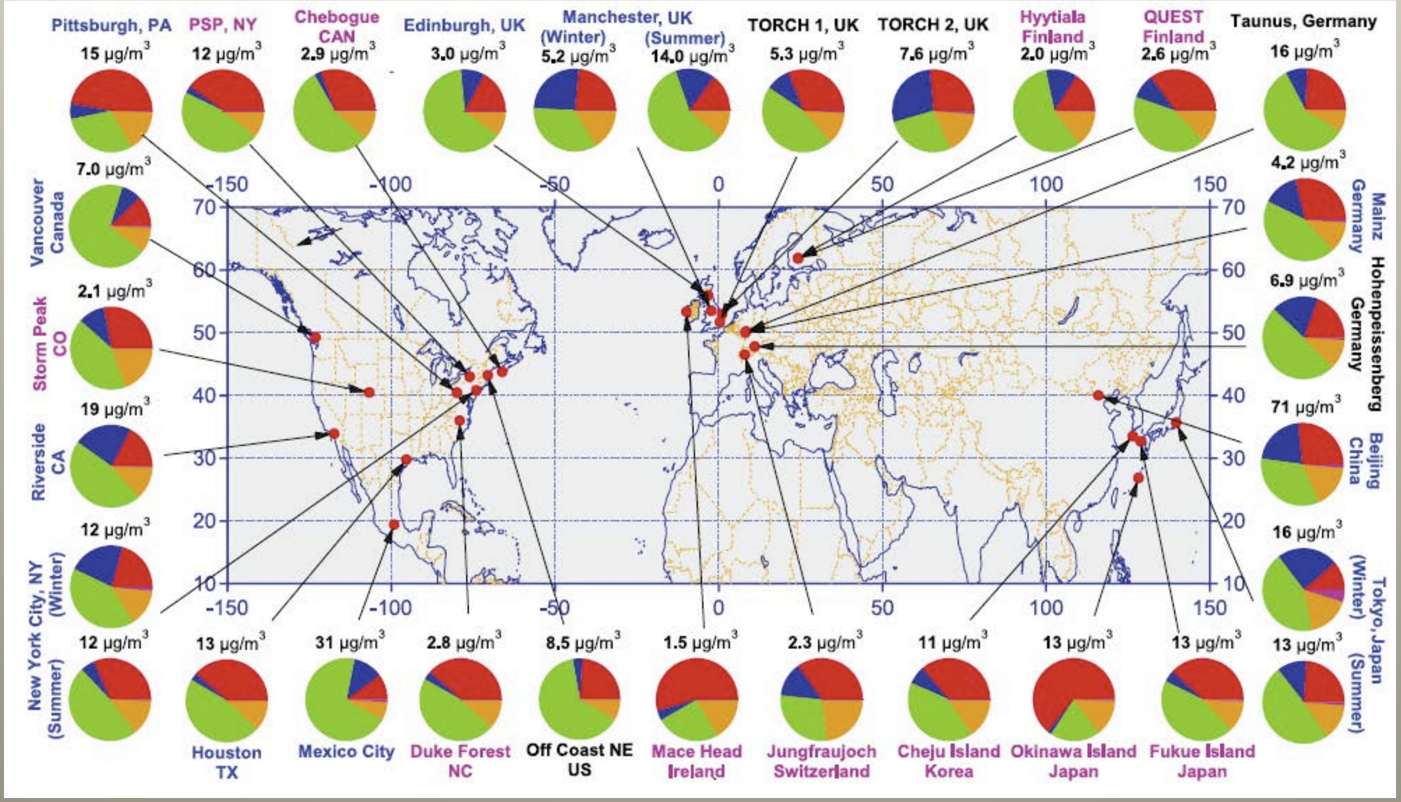
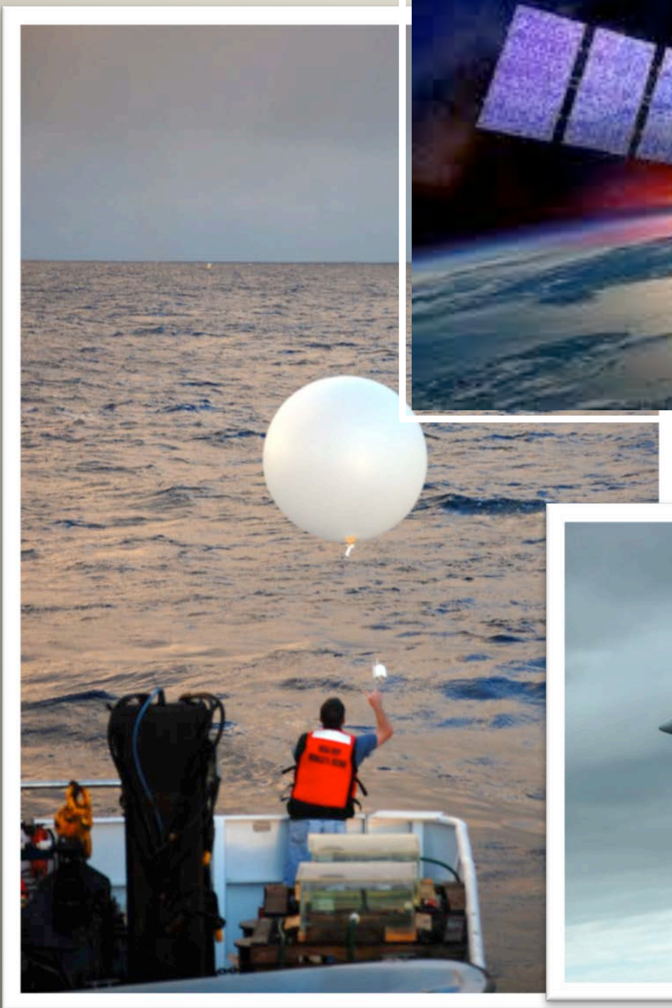
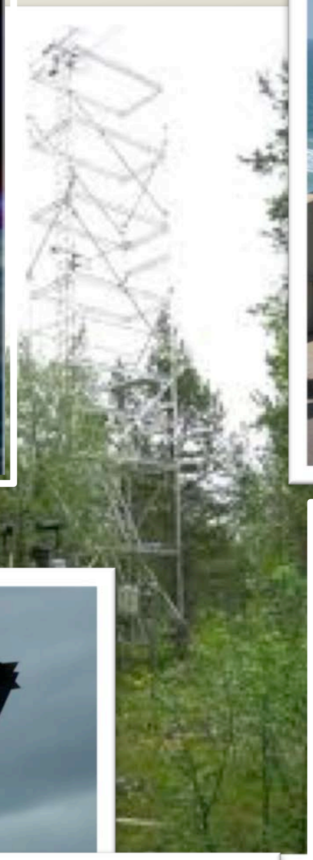
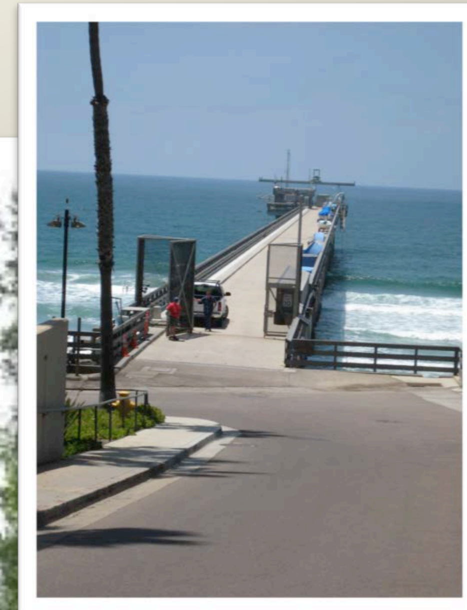


Figure from Zhang et al., 2007 GRL

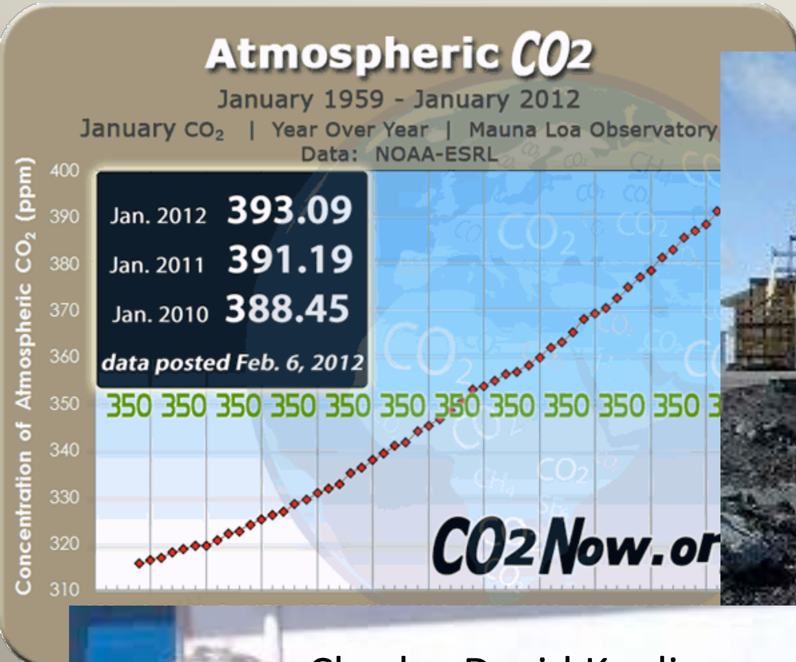
Where are measurements made? And how?







One of the most important atmospheric measurements of our time



Charles David Keeling

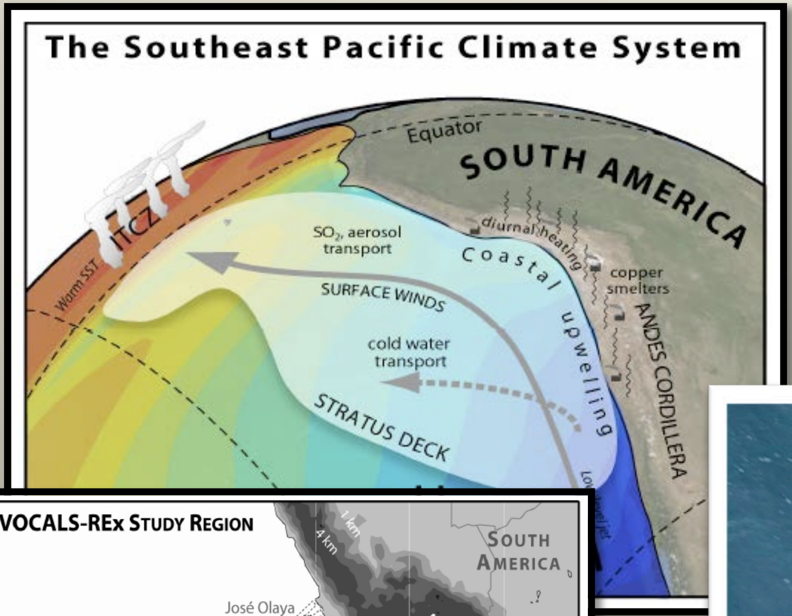
Importance of collaboration

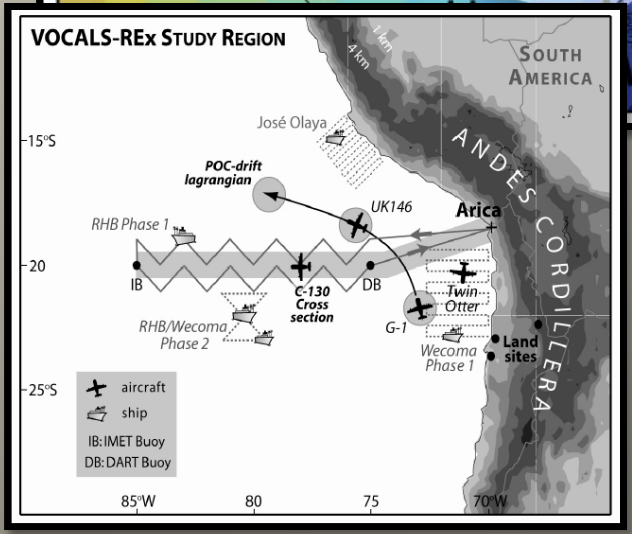
Calnex Field Study

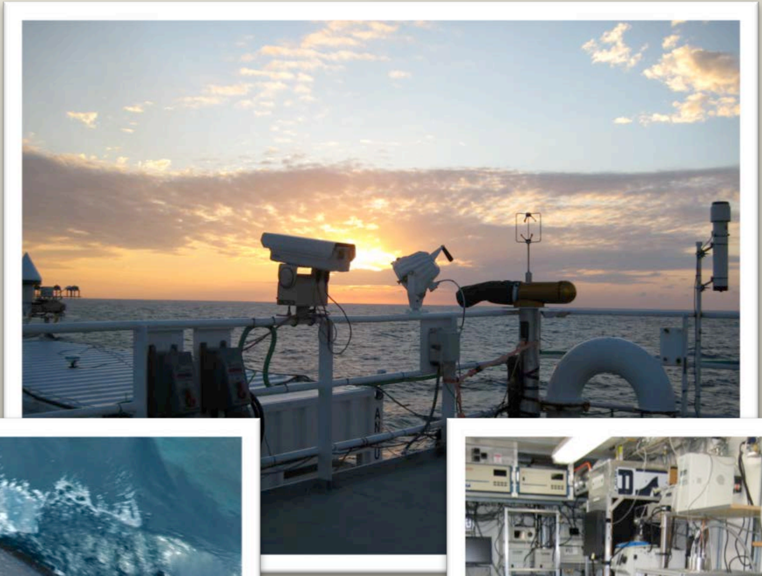
MILAGRO, Mexico City

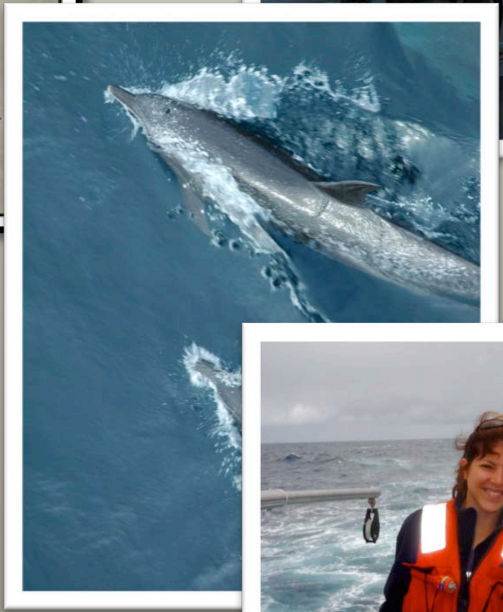
Inside a C-130 airplane during MILAGRO

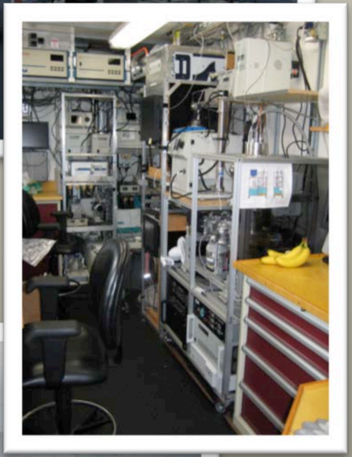
VAMOS Ocean-Cloud-Atmosphere Land-Study Regional Experiment (VOCALS-REx)







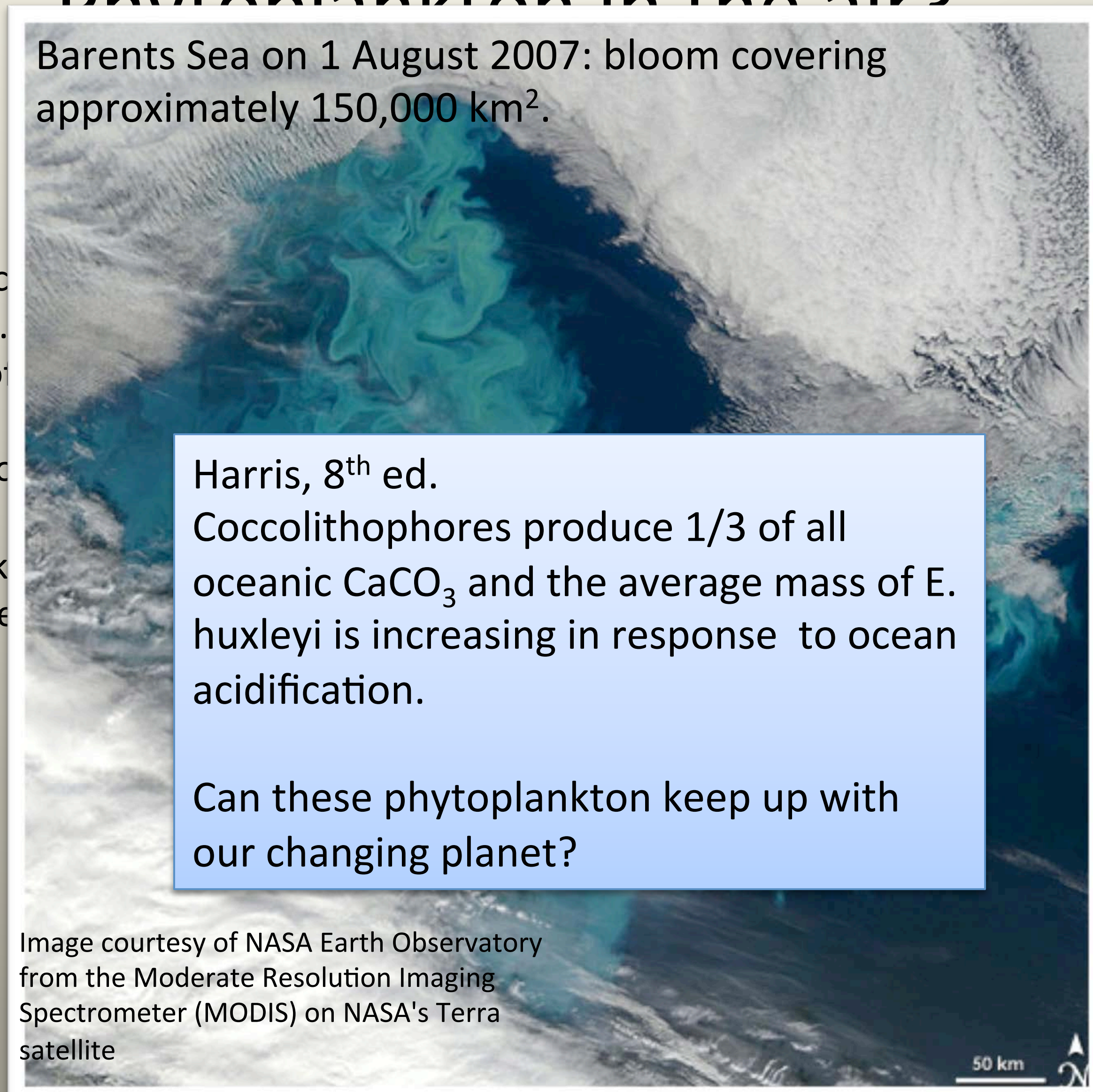




Wood et al., 2007 Program Summary

Calcareous Phytoplankton Fragments: Phytoplankton in the air?

• Particles enric … phores [Sievering et al.
• Other types o … Leck and Bigg, 1999;2005].
• Coccolithopho … many repeating units of $-CH_2$.
•Previously unk … to sizes larger than 1 microme



Barents Sea on 1 August 2007: bloom covering approximately 150,000 km^2.

Harris, 8th ed.
Coccolithophores produce 1/3 of all oceanic $CaCO_3$ and the average mass of E. huxleyi is increasing in response to ocean acidification.

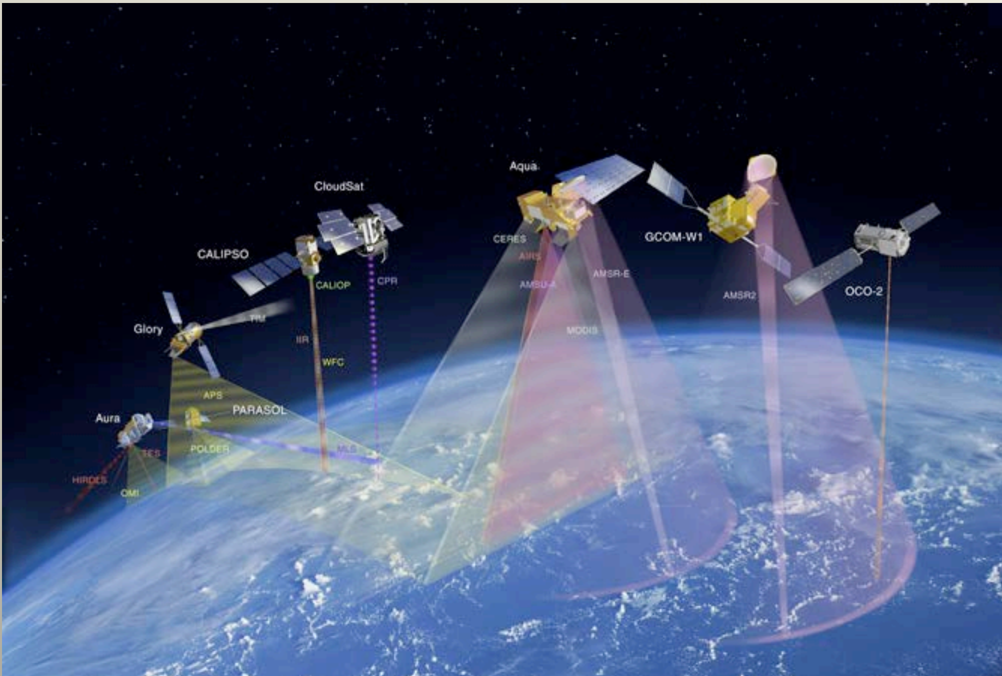
Can these phytoplankton keep up with our changing planet?

Image courtesy of NASA Earth Observatory from the Moderate Resolution Imaging Spectrometer (MODIS) on NASA's Terra satellite

Emiliania huxleyi

Hawkins and Russell, 2010b

NASA’s A-Train

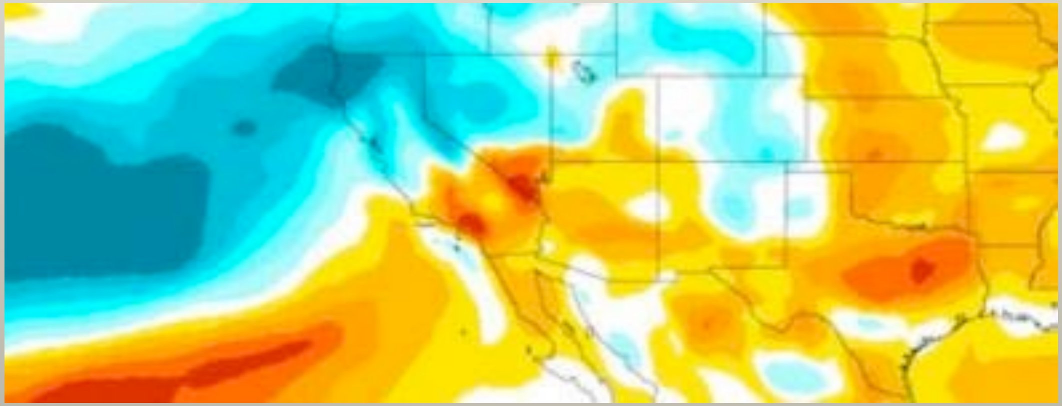


- Crosses the equator around 1:30 pm daily.
- Together they measure water vapor, temperature, rainfall, clouds, aerosols, greenhouse gases and more.

What is the overall affect of aerosols and clouds on climate? How much carbon is absorbed by forests? How will the monsoon cycle react to a warming world? To what extent will a changing climate change the size and strength of hurricanes? And what feedback cycles will encourage or discourage climate change?

A great place to know about: NCAR

- Models



- Measurements

- Black carbon and sea ice

What might rockets add?

- Climate model “ground truthing”
- Repeatable, local measurements
- Very high altitude studies (not yours!), most useful above altitude for balloons (40 km) and below satellites (recall collaboration!).
- Lower cost than a fully instrumented aircraft
- Can be launched from remote locations (ships etc).
- Vertical profiles help meteorologists understand weather
- Complement ground based measurements
- Can be launched at short notice of phenomena

What I'd find interesting to measure by rocket

- Temperature, pressure, light intensity, relative humidity, and average wind speed.
- Trace gas concentration and particulate concentration.
- Could you collect a sample of particulates?
- Can you think of anything to add?