



# Predicting Climate and its Change A Global Climate Modeling and Applications of using Satellites measurements

Jui-Lin (Frank) Li  
Jet Propulsion Laboratory, California Institute of Technology

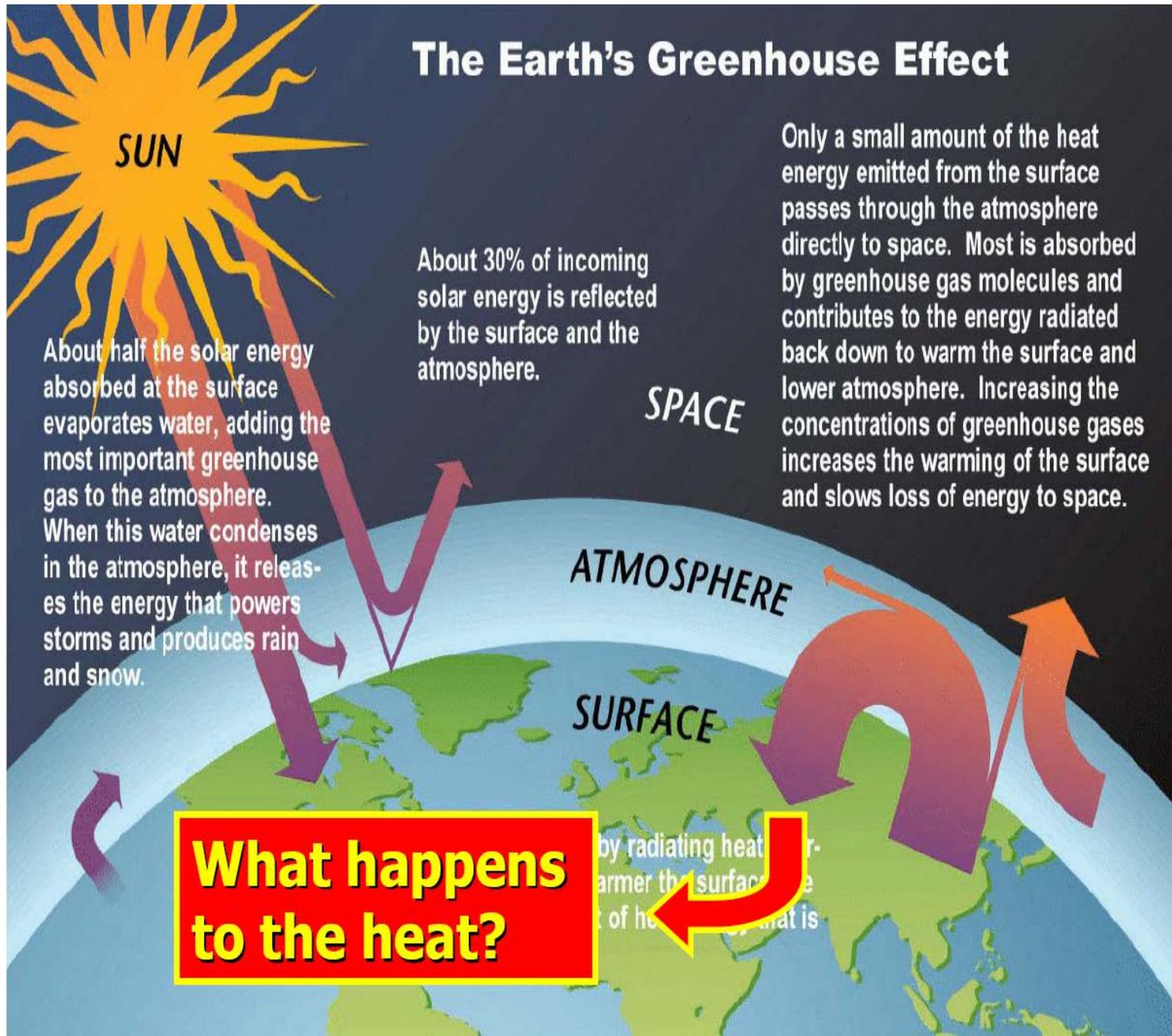
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Photo source: World Food Program

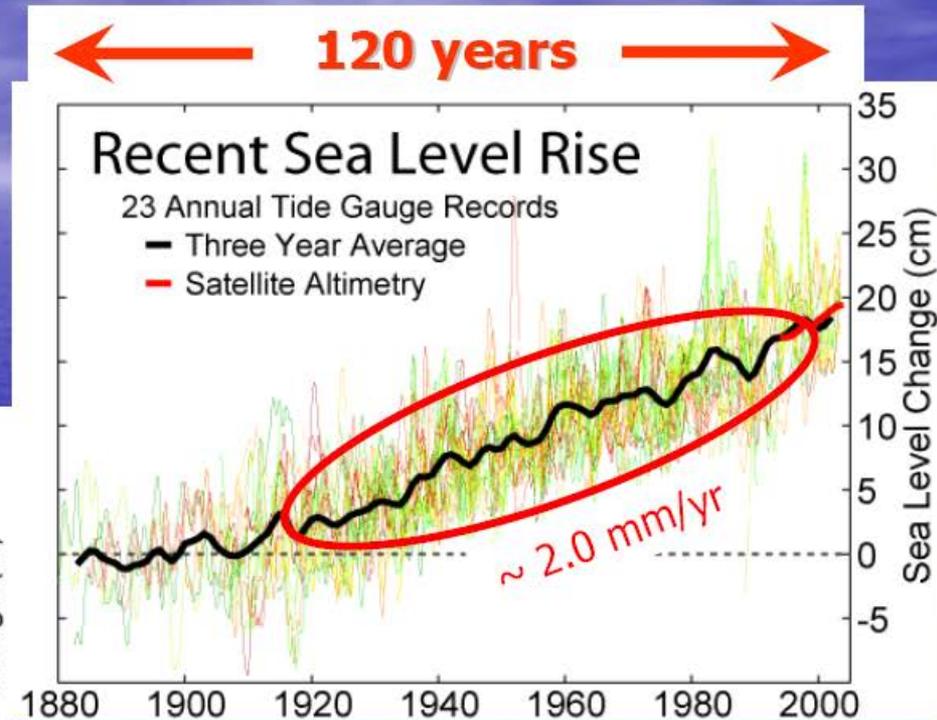
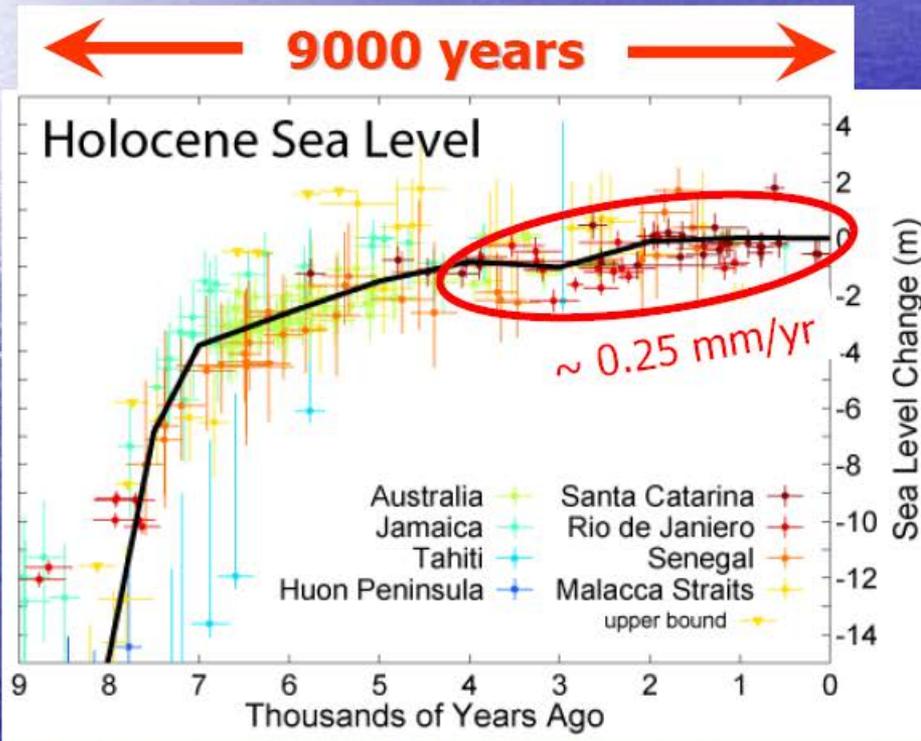


# The Earth's Greenhouse Effect



**What happens to the heat?**

# Historic Sea Level Rise



Recent rates of sea level rise are 100 times larger than historic rates.



# The Climate Change

## Natural Variations

Geological Changes e.g. Volcanoes  
El Nino; La Nina

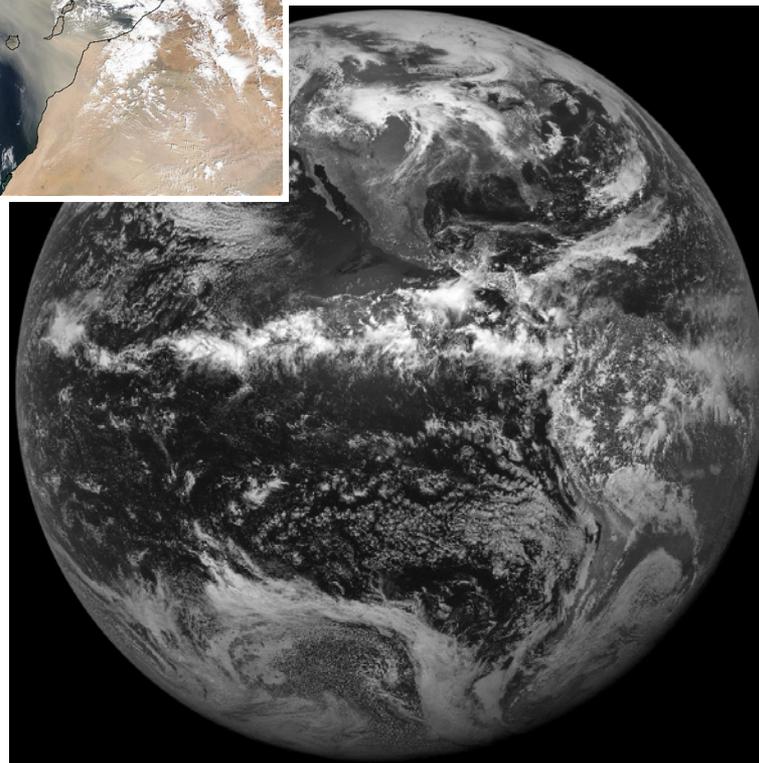
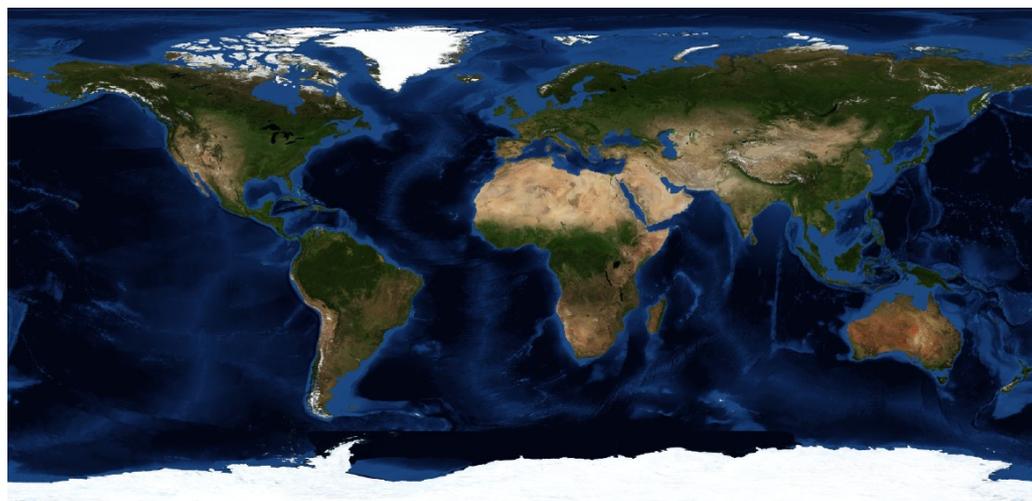
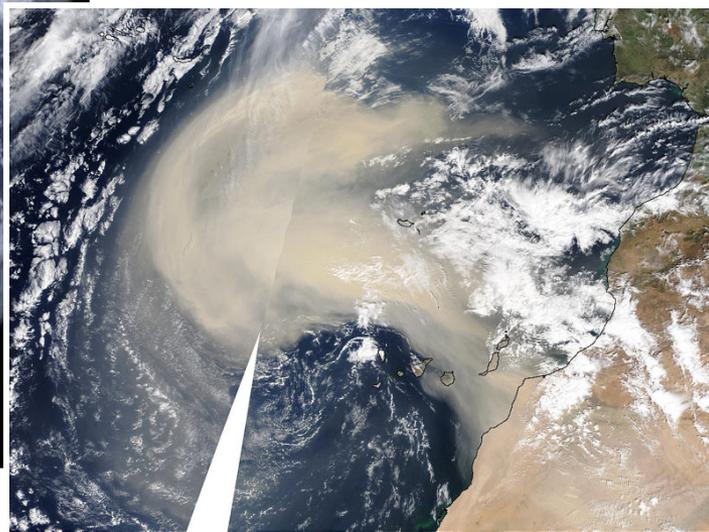
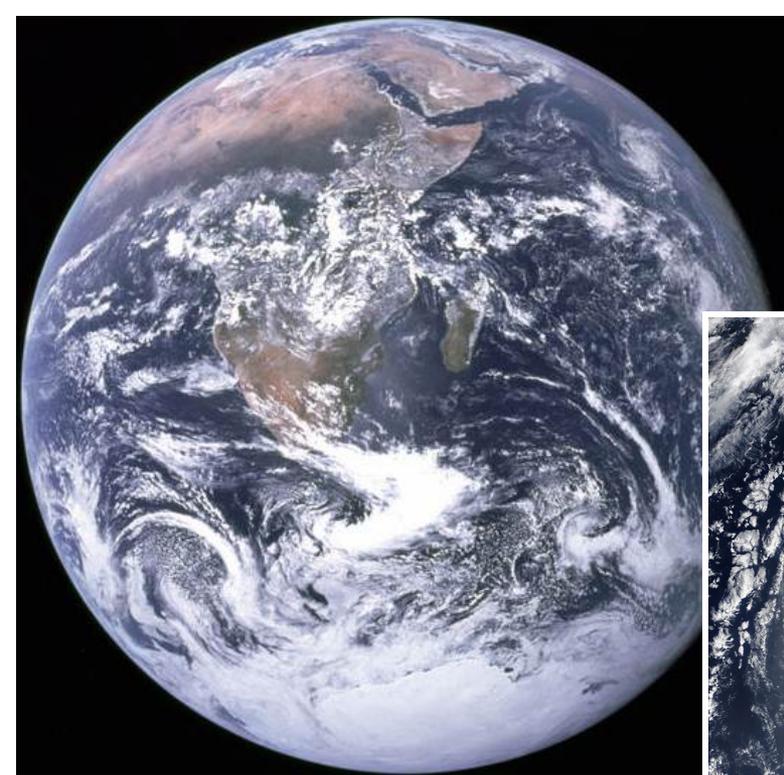
## Man Made Anthropogenic

Enhanced Greenhouse Gases (e.g., CO<sub>2</sub>)



# Clouds, Ice, Snow, Deserts and Dust

Reflects  
Sunlight  
Back to  
Space



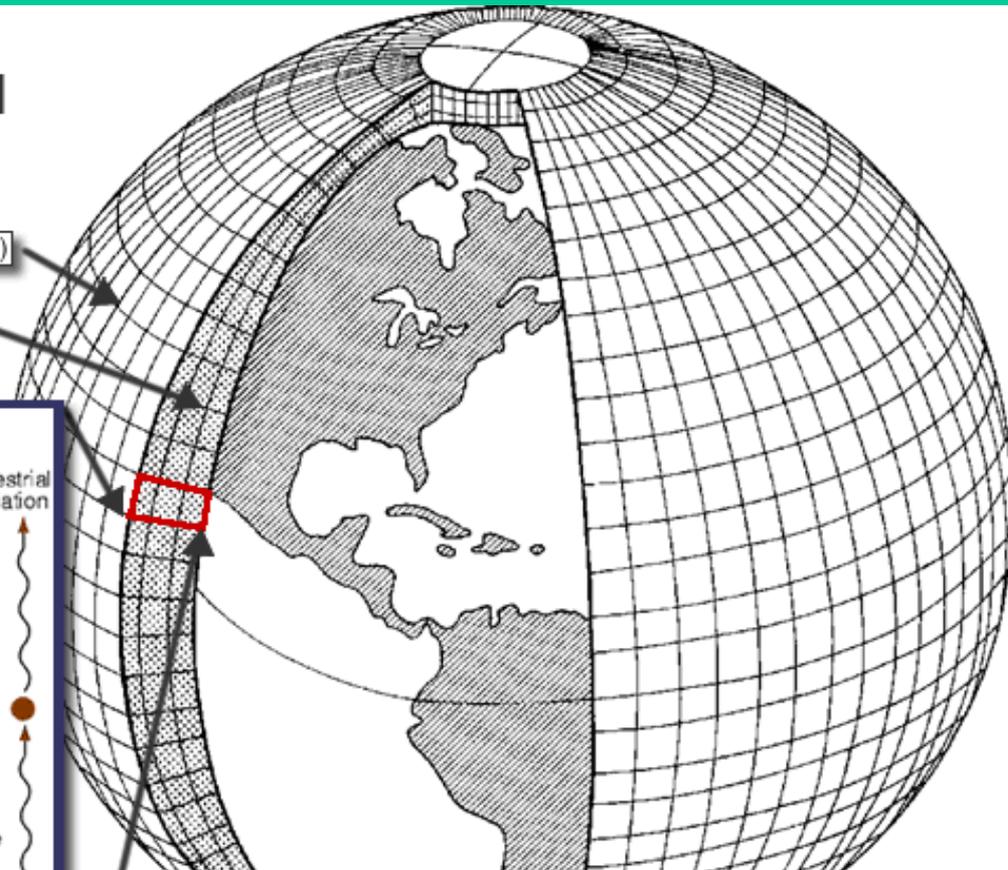
# Climate Model Computer "Grid"



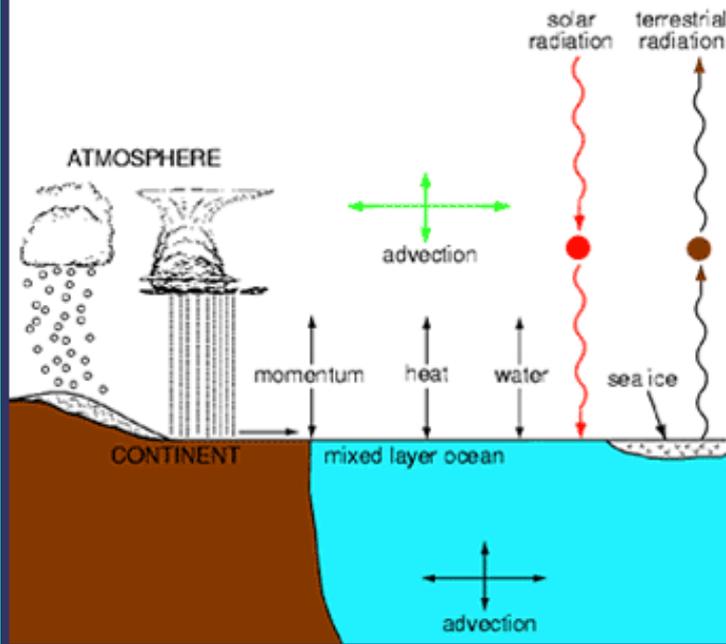
## Schematic for Global Atmospheric Model

Horizontal Grid (latitude - longitude)

Vertical Grid (height or pressure)



### Physical Processes in a Model



Similar for Ocean,  
Land & Ice Systems



# That's Why We Need Super-Computers



**JPL Dell Xeon Cluster**  
[cosmos.jpl.nasa.gov](http://cosmos.jpl.nasa.gov)



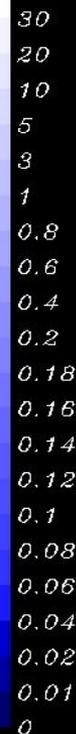
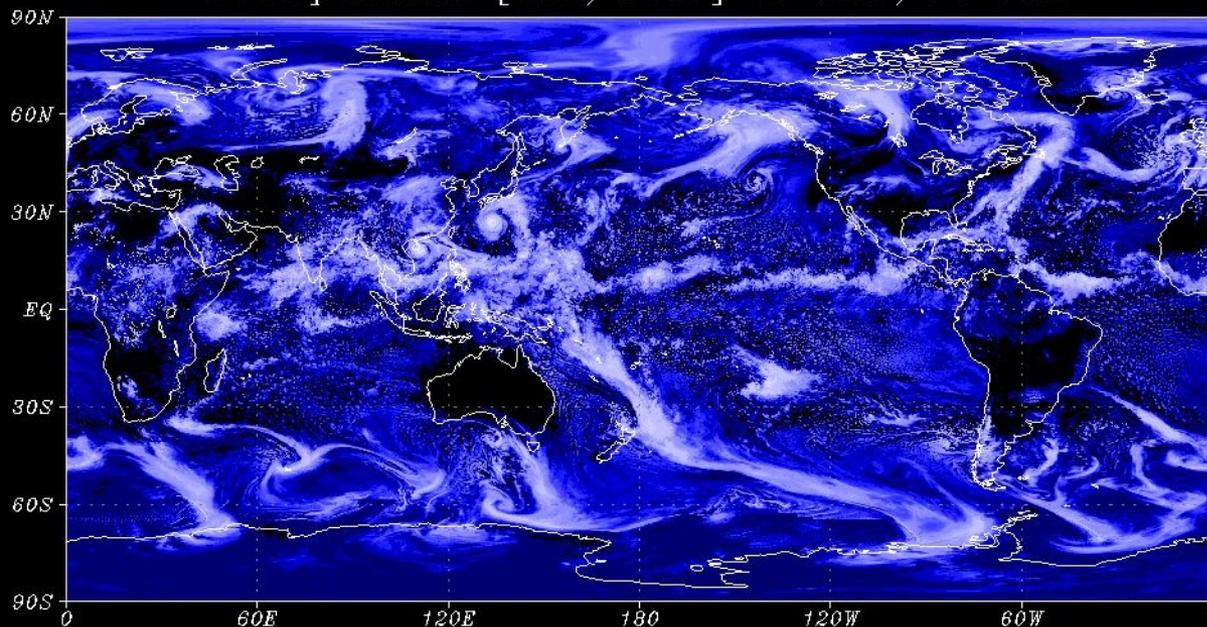
- 1) Get More Numbers
- 2) Make Sure it is

10km Grid  
Our Excel ~ 100 km  
10,000 X More Work



Earth Simulator Center

AFES T1279L96  
Precipitation [mm/hour] 03 SEP/17 12Z



Longest  
Simulations  
A Few Months

Incoming solar radiation

In Summer and/or Daytime  
SW radiative effect dominate land  
Competition between SW & LW radiative effects

Reflected by cloud and atmosphere

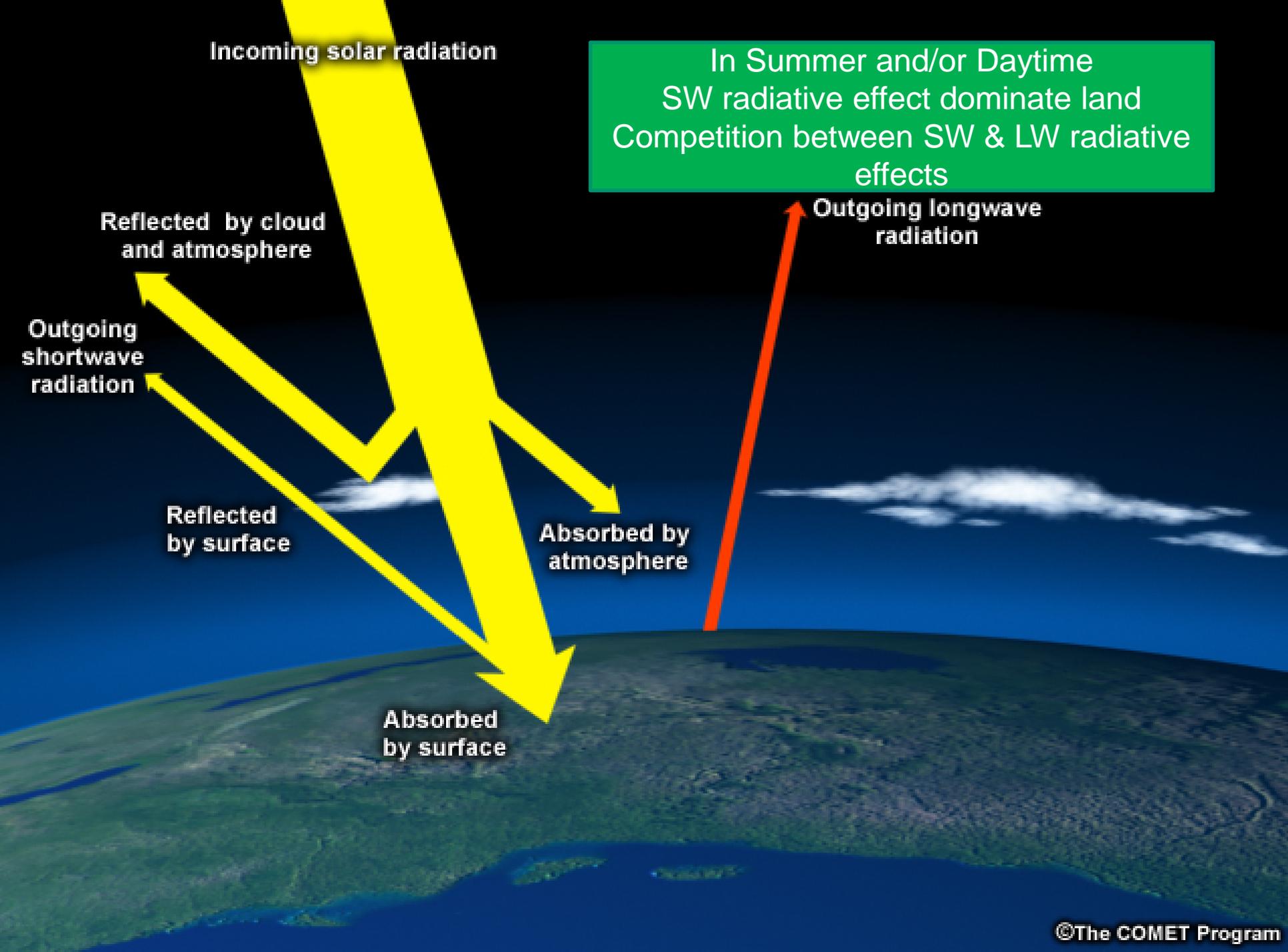
Outgoing shortwave radiation

Reflected by surface

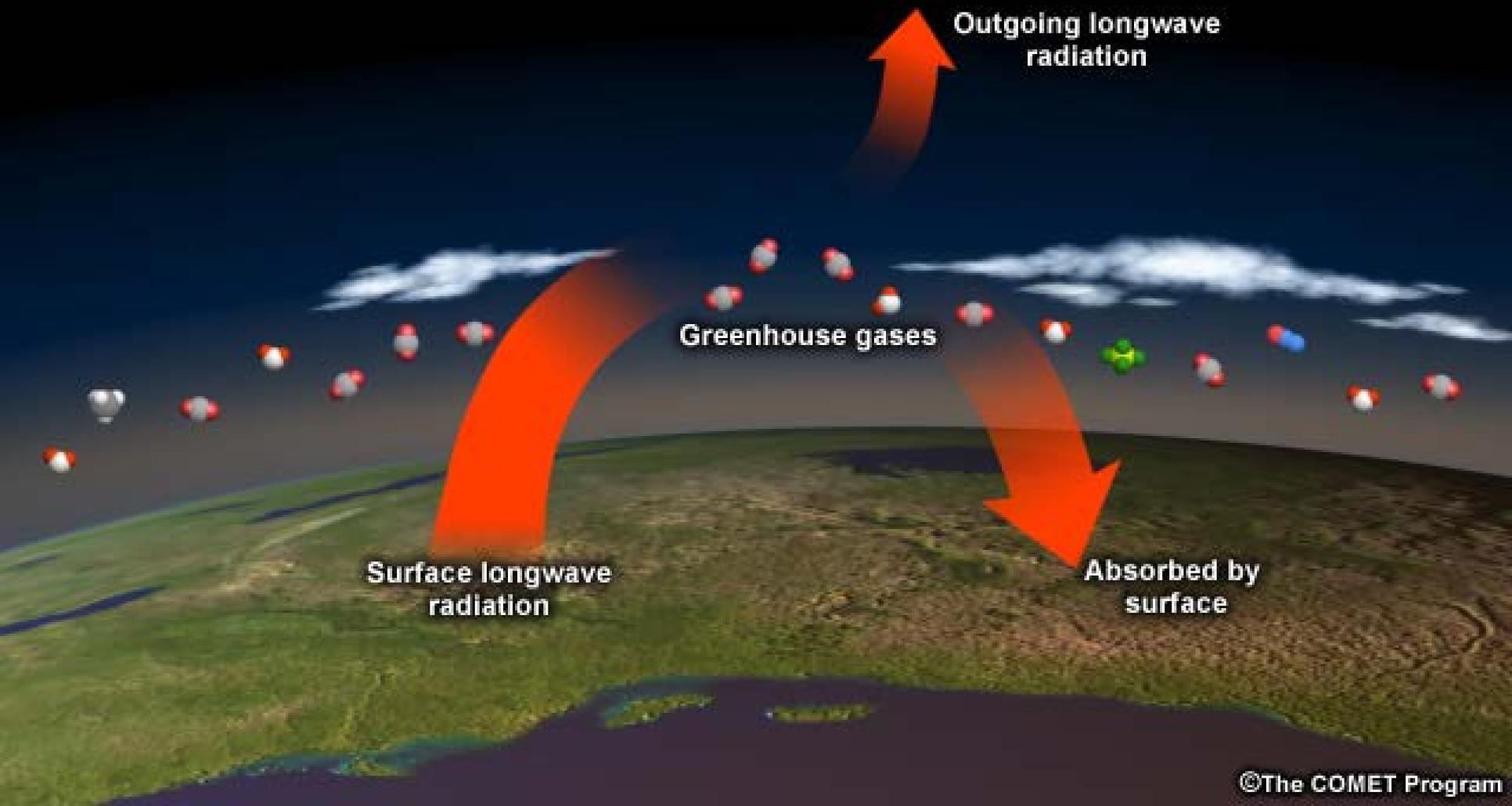
Absorbed by atmosphere

Absorbed by surface

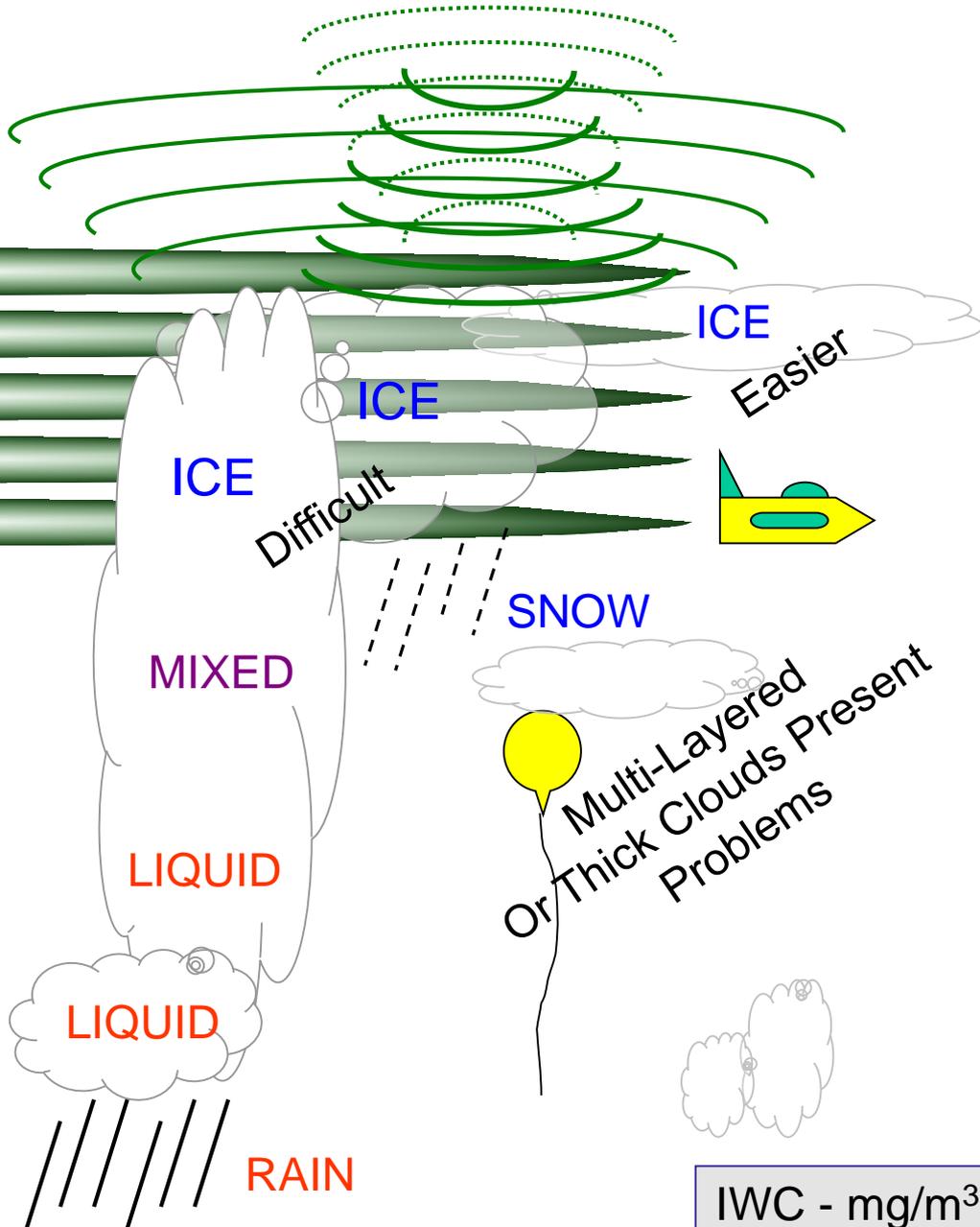
Outgoing longwave radiation



In winter and/or nighttime  
LW radiative effect dominate over land



# MEASUREMENT STRATEGIES: NEW OPPORTUNITIES



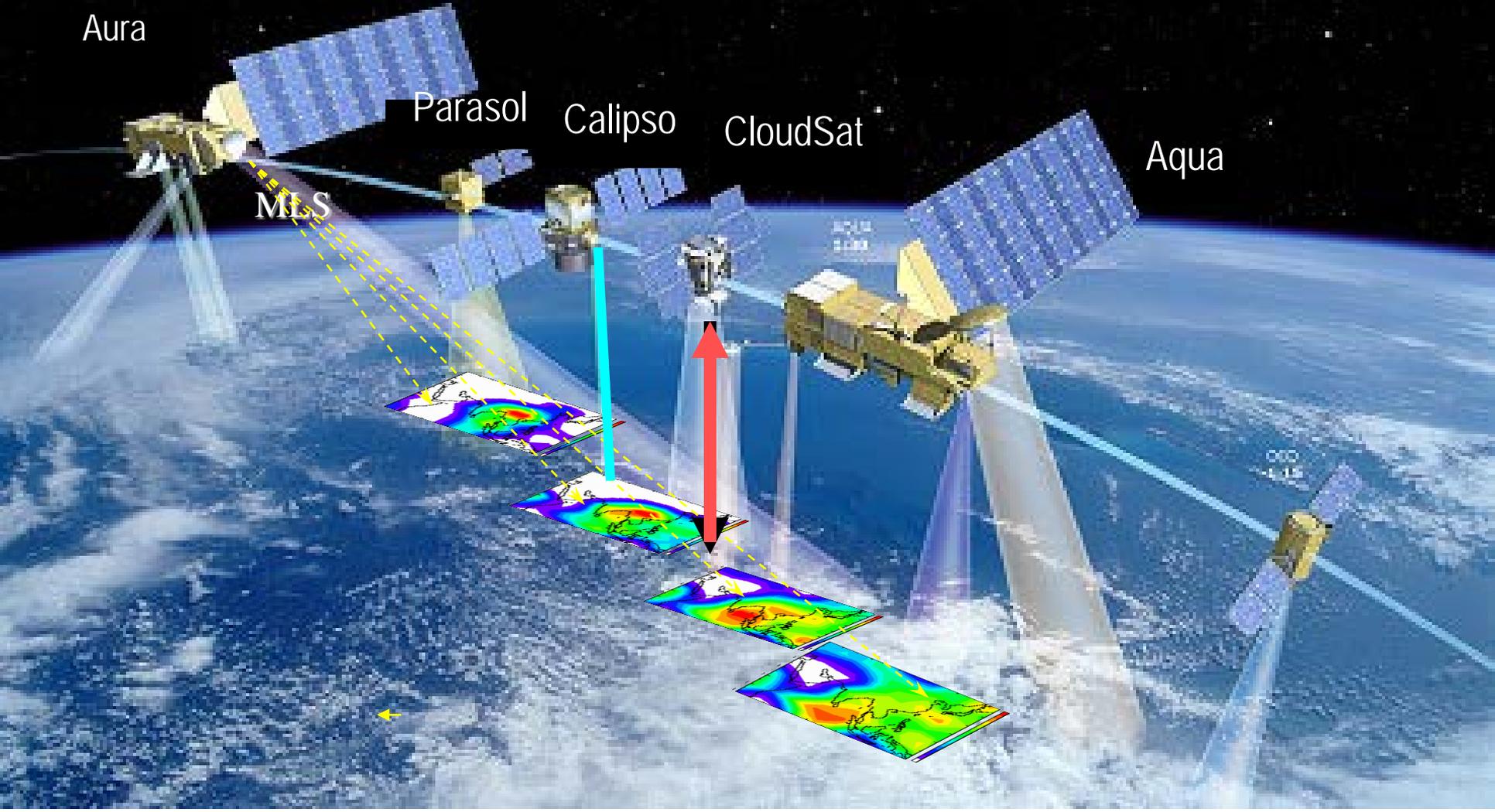
PASSIVE TECHNIQUES SUCH AS THOSE USED IN THE CERES/MODIS, ISCCP, MODIS, AND NOAA/MW PRODUCTS ONLY PROVIDE TOTAL IWP ESTIMATES - CHALLENGING IN MULT-LAYER, MIXED AND THICK CLOUDS.

MLS - A LIMB SOUNDER - CAN PROBE THE UPPER TROPOSPHERE TO ESTIMATE IWC (BUT NOT TOTAL IWP)

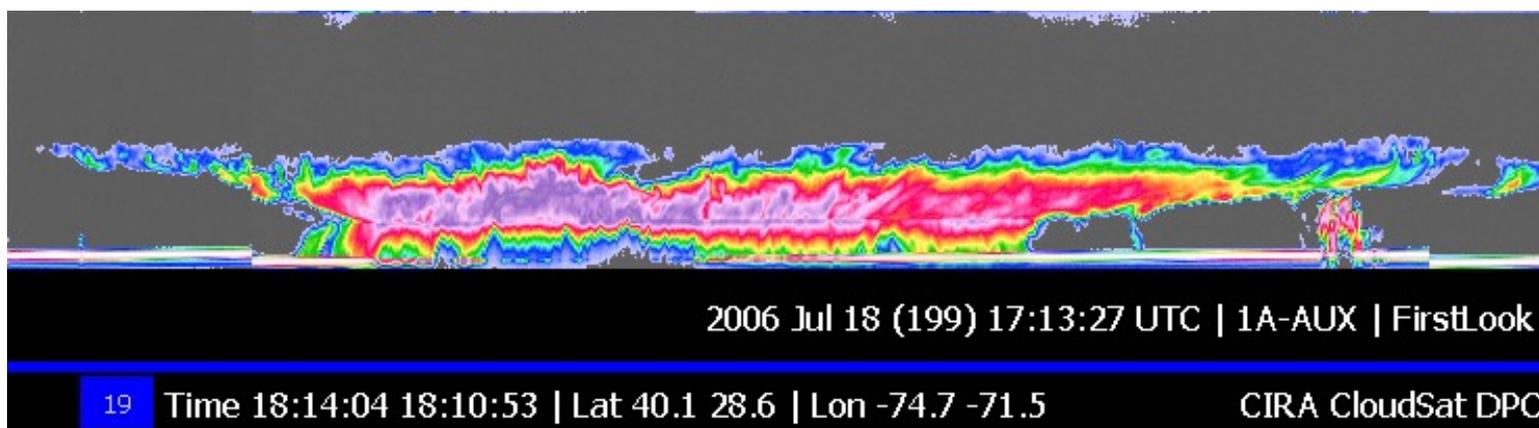
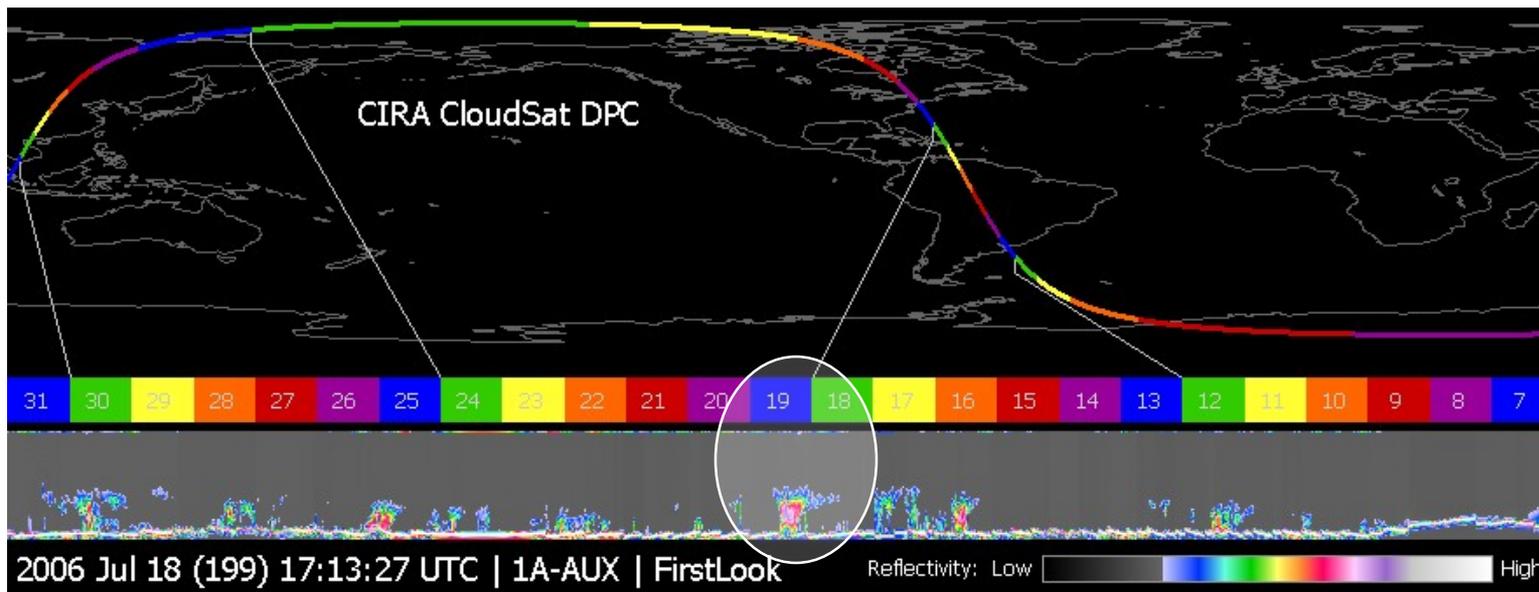
CLOUDSAT (CLOUD RADAR) AND CALIPSO (LIDAR) CAN PROBE THE CLOUD STRUCTURE AND PROVIDE ESTIMATES OF IWC. CLOUDSAT ALSO PROVIDES IWP.

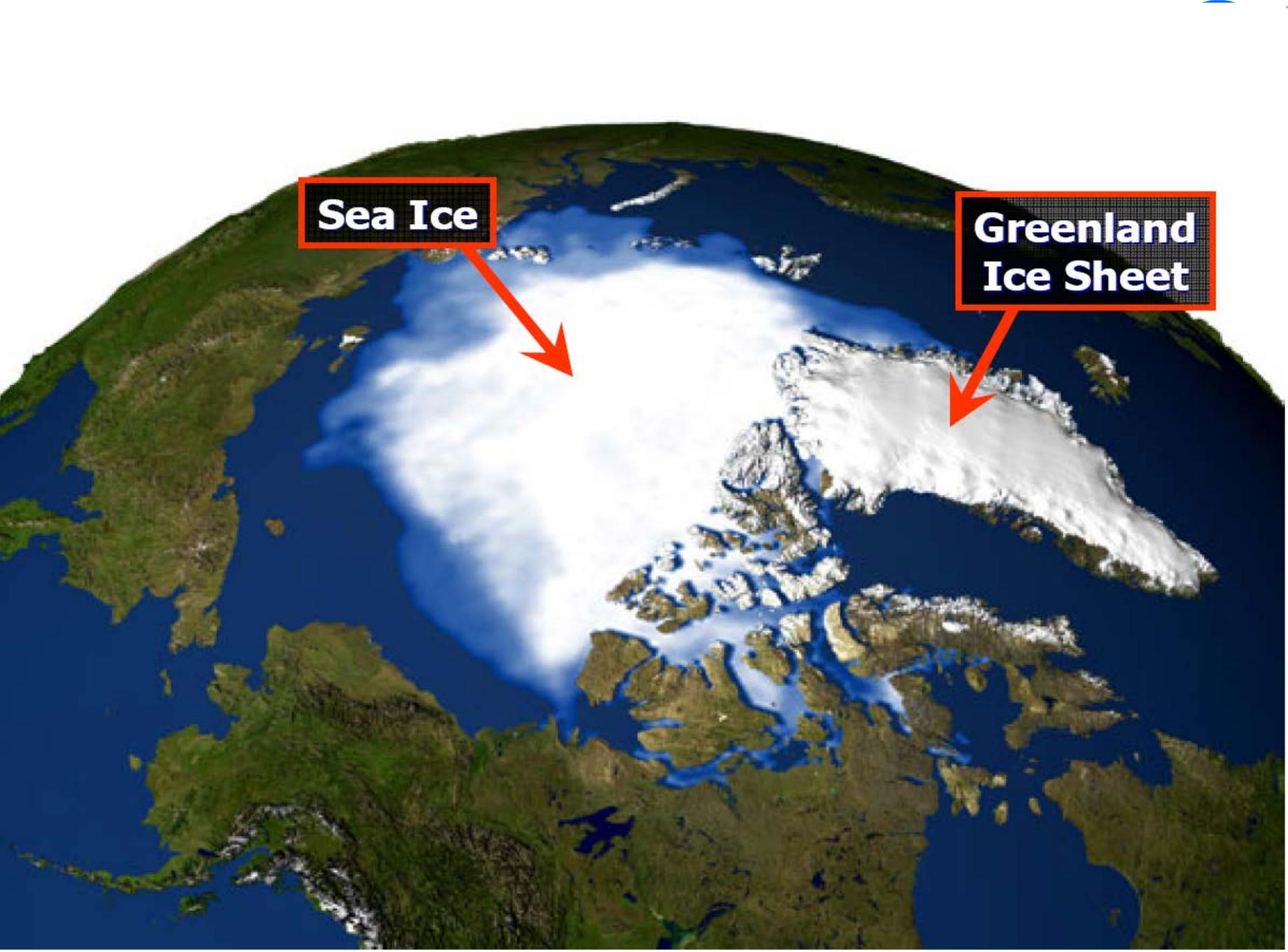
IWC -  $\text{mg}/\text{m}^3$   
IWP -  $\text{mg}/\text{m}^2$

Satellite data such as MLS/CloudSat/CALIPSO provide an opportunity for validating and constraining models, to identify/improve the hydrological and dynamical processes



# CloudSat : Cloud Radar!

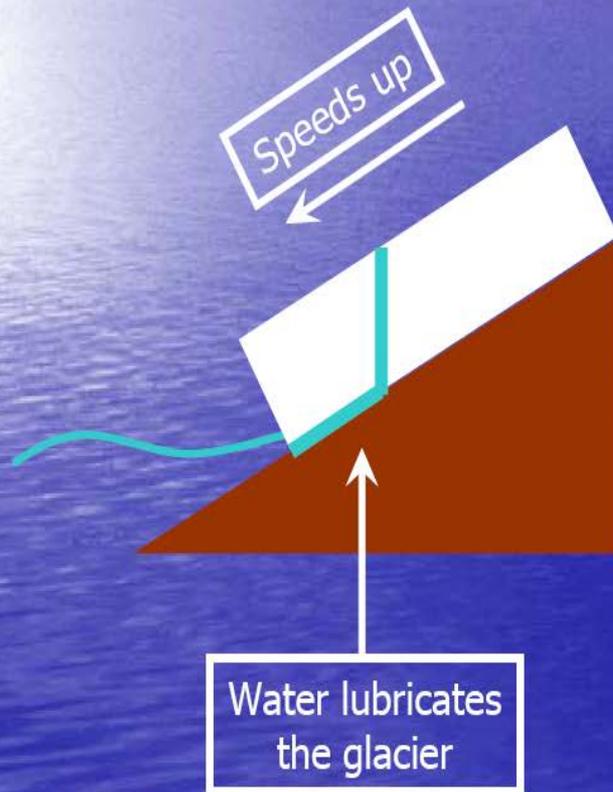




**Sea Ice**

**Greenland  
Ice Sheet**

# Ice Sheet melting



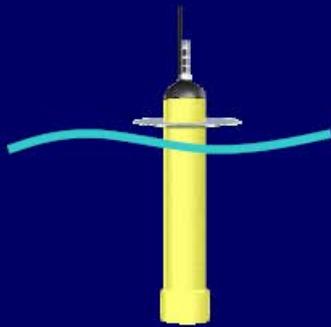


# Accelerated ice discharge

Difficult to predict sea level rise!!!

# Measuring the World's Oceans

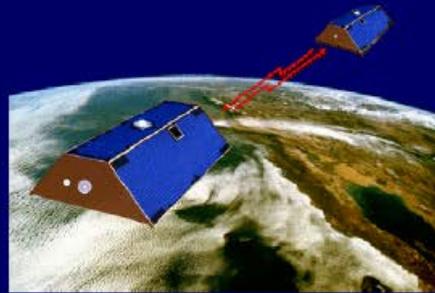
addition of heat



Argo

+

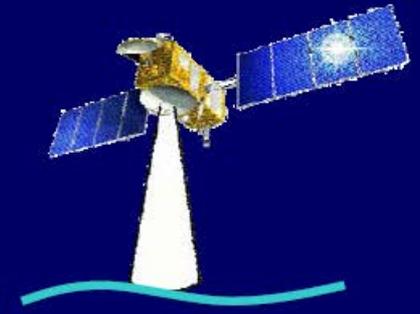
addition of freshwater



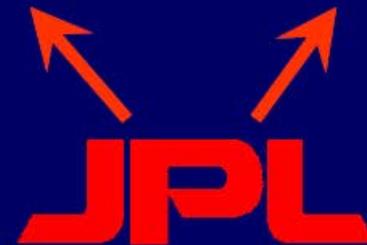
GRACE

=

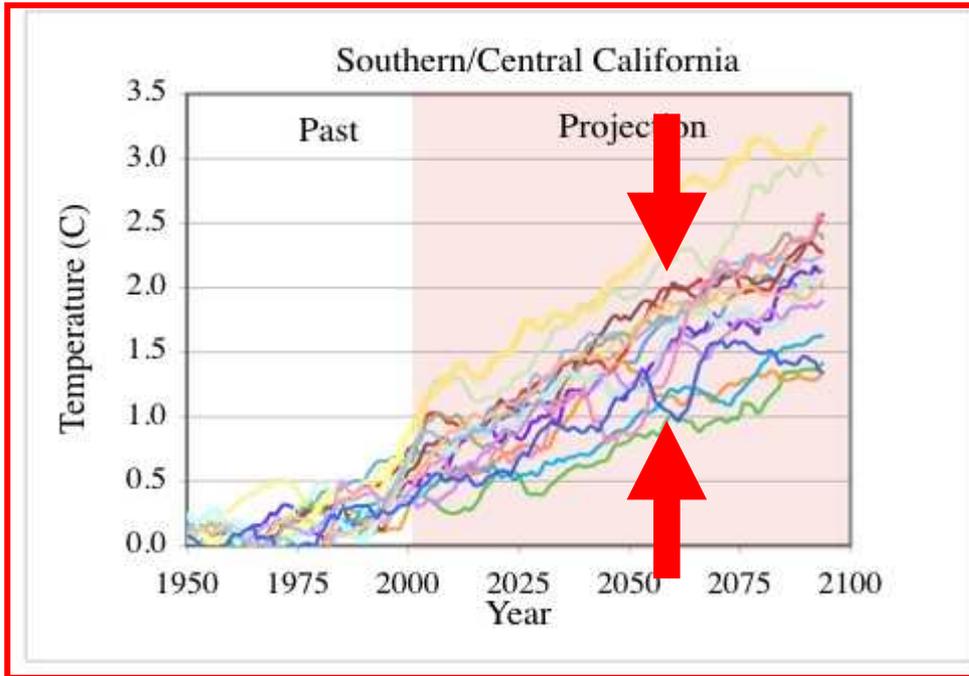
Total sea level rise



Jason



# Reducing Remaining Uncertainties



- Better/More Measurements
- Faster/Better Computers & Infrastructure
- Continued Dedication & Focus

