

# CLIMATE MODELING

SPRING 2010

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# BASICS

- ED GERBER ([GERBER@CIMS.NYU.EDU](mailto:GERBER@CIMS.NYU.EDU))
  - LECTURES, TUESDAY 9:30-11:20
  - OFFICE HOURS TUESDAY 2-4 OR BY APPT.
- EXPECTATIONS
  - ATTEND LECTURES, READ BACKGROUND MATERIAL
  - COURSE PROJECT
    - RUN AND/OR ANALYZE A CLIMATE MODEL
    - INVESTIGATE A CLIMATE QUESTION (MORE ON THAT LATER!)

# RESOURCES

## ■ TEXTBOOKS

■ A CLIMATE MODELLING PRIMER  
(KENDAL MCGUFFIE + ANN HENDERSON-SELLERS)

■ FUNDAMENTALS OF ATMOSPHERIC MODELING  
(MARK JACOBSON)

■ AN INTRODUCTION TO 3-D CLIMATE MODELING  
(WARREN WASHINGTON + CLARA PARKINSON)

## ■ HISTORY + CONTEXT

■ AN OCEAN OF AIR (GABRIELLE WALKER)

■ THE DISCOVERY OF GLOBAL WARMING  
(SPENCER WEART)

# WHERE TO BEGIN

## ■ VILHELM BJERKNES (1904)

If it is true, as every scientist believes, that subsequent atmospheric states develop from the preceding ones according to physical law, then it is apparent that the necessary and sufficient conditions for the rational solution of forecasting problems are the following:

1) A sufficiently accurate knowledge of the state of the atmosphere at the initial time.

2) A sufficiently accurate knowledge of the laws according to which one state of the atmosphere develops from another.

# INITIAL CONDITIONS + EXTERNAL FORCING

- COMPOSITION OF THE ATMOSPHERE + OCEAN + CRYOSPHERE + LAND SURFACE
- FORCING TRENDS (NATURAL + ANTHROPOGENIC)
- CLIMATOLOGY OF TODAY
  - OCEAN HEAT CONTENT
  - ICE, LAND SURFACE (CHEMISTRY, BIOLOGY)

# EQUATIONS OF CLIMATE

## ■ ATMOSPHERE

- HEAT+MASS (WATER!!) TRANSPORT, ALBEDO (CLOUDS, AEROSOLS), RADIATION EFFECTS (GREENHOUSE), CHEMISTRY

## ■ OCEAN

- HEAT TRANSPORT AND STORAGE, CHEMICAL UPTAKE AND STORAGE

## ■ CRYOSPHERE (ICE SHEETS, GLACIERS, SEA ICE)

- ALBEDO, AIR-SEA INTERACTIONS, SEA LEVEL

## ■ LAND PROCESSES

- CHEMISTRY (CARBON UPTAKE), AEROSOLS, ALBEDO

# A BIT OF HISTORY

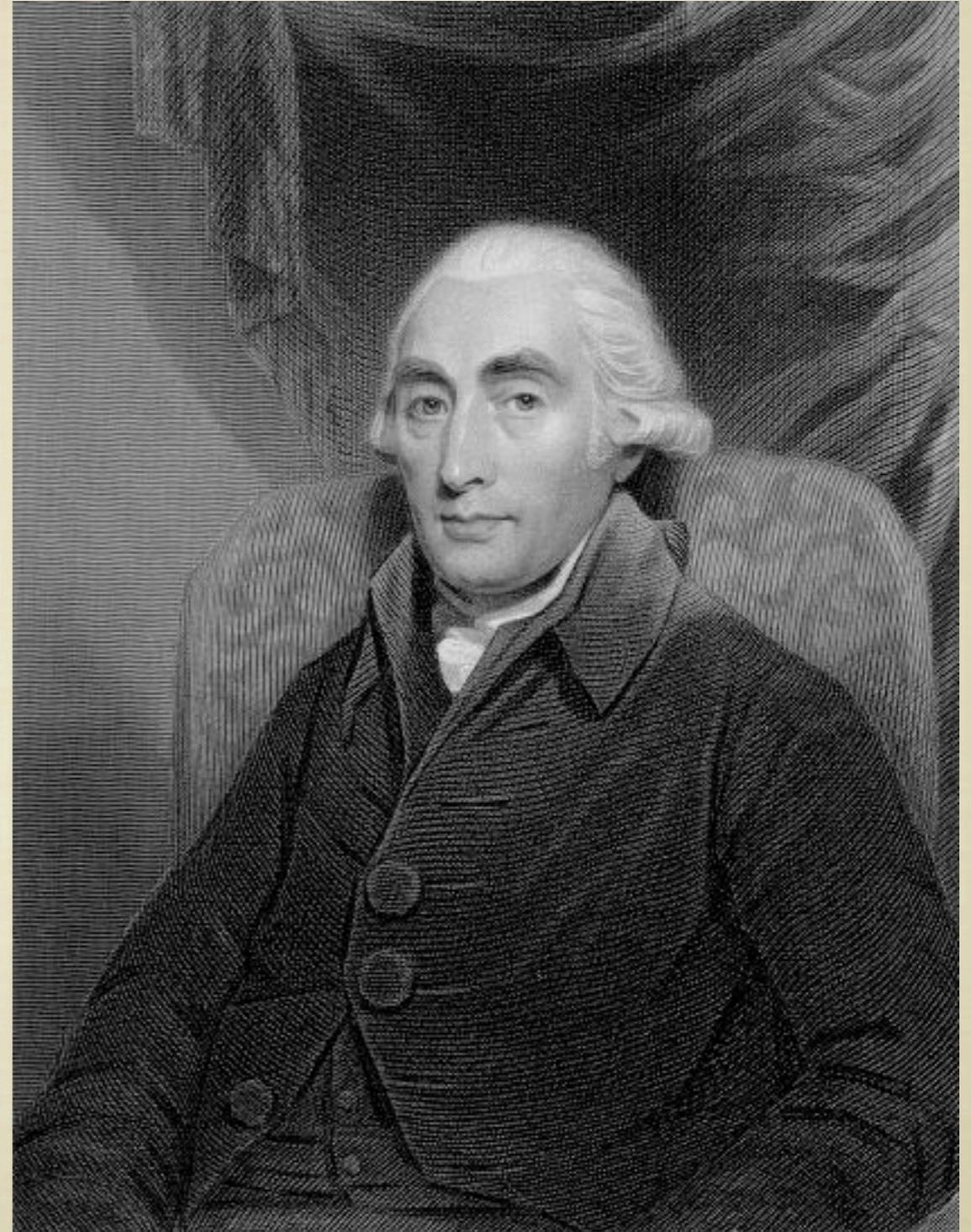
**JOSEPH FOURIER  
1824 PAPER**

**WORLD WARMER  
THAN IT OUGHT TO  
BE -- ATMOSPHERE  
TRAPPING INFRARED  
RADIATION**



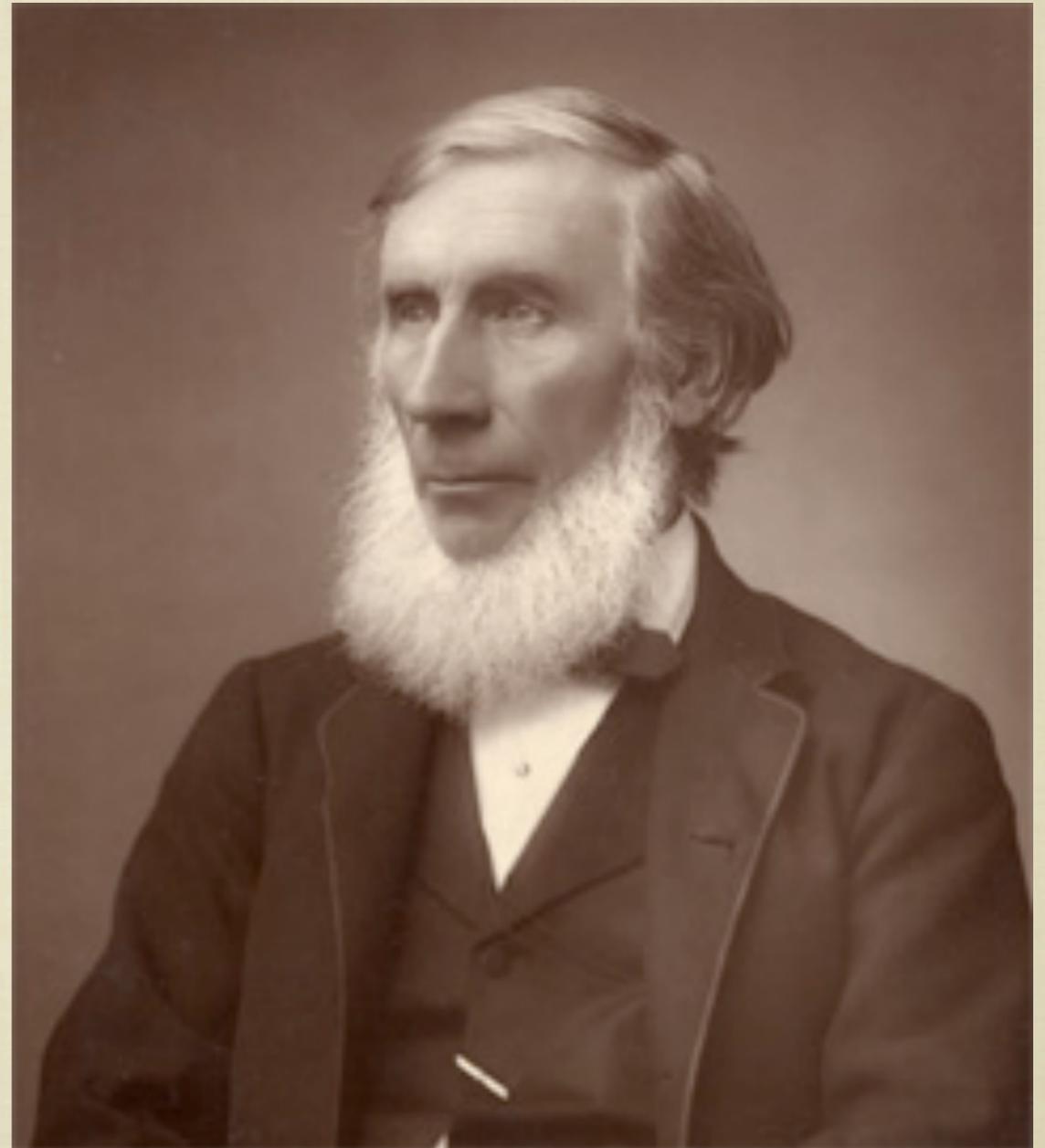
# A BIT OF HISTORY

**JOSEPH BLACK  
DISCOVERED CO<sub>2</sub>  
“FIXED AIR” IN 1754  
[ALSO DISCOVERED  
LATENT HEAT]**



# A BIT OF HISTORY

**JOHN TYNDALL**  
**1850s - CONFIRMED**  
**THAT CO<sub>2</sub> (0.04% OF**  
**ATMOSPHERE), WATER**  
**VAPOR ARE EFFECTIVE**  
**ABSORBERS OF**  
**“RADIANT HEAT” (THAT**  
**IS, INFRARED LIGHT)**



# A BIT OF HISTORY

**SVANTE ARRHENIUS**

**1896**

**SEVERAL MONTHS OF**

**CALCULATIONS:**

**CUT CO<sub>2</sub> IN HALF,  
H<sub>2</sub>O ADJUSTS, ATMO  
COOLS 5 K (HE WAS**

**TRYING TO**

**UNDERSTAND ICE**

**AGES)**



# A BIT OF HISTORY

**ARVIG HÖGBOM  
CO<sub>2</sub> INCREASING  
FROM ANTHROPOGENIC  
ACTIONS**

**ARRHENIUS REDID  
COMPUTATIONS,  
DOUBLING CO<sub>2</sub>  
RAISES TEMP 5 K!**



# COMPLICATIONS . . .

- RADIATION IS COMPLEX: CO<sub>2</sub> ABSORPTION BANDS MAY SATURATE
- OCEANS CONTAIN 50 TIMES THE CO<sub>2</sub>, COULD EASILY SOAK UP ALL EMISSIONS!
- WATER VAPOR FEEDBACK IS KEY -- WHAT IF CLOUDS INCREASE ALBEDO?
- TO THE BLACKBOARD TO GET STARTED . . .