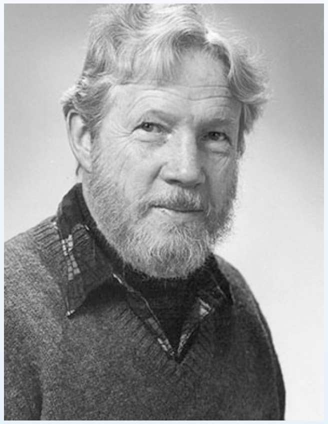
Atmospheric Chemistry and Dynamics: 1965-2015

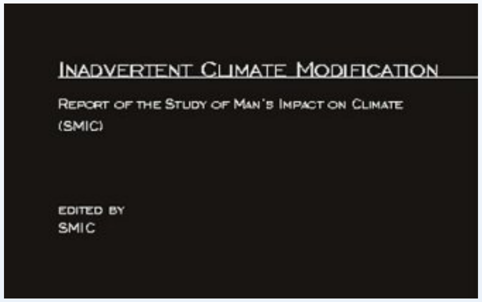
1965 Colloquium Speakers:



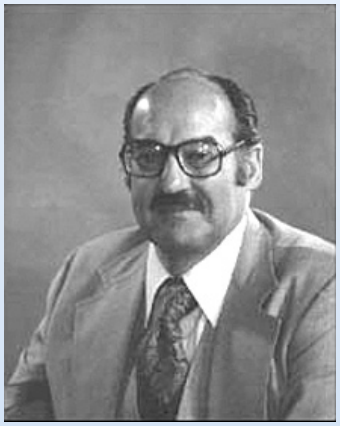
William W. Kellogg

Head, NCAR Laboratory of Atmospheric Sciences; 1964

Organizer, SMIC (Study of Man's Impact on Climate); Report 1971



"Physics, Chemistry and Dynamics of the Atmosphere."



Joseph Smagorinsky

Head/Founder Geophysical Fluid Dynamics Laboratory:

Originally General Circulation Research Section of US Weather Bureau, 1955: Renamed and moved to Princeton, NJ in 1968

"Theoretical Modeling of the Atmosphere's General Circulation."

Atmospheric Chemistry: Where were we?

1965

Scattered papers on atmospheric composition and role of chemistry with little recognition that chemicals might affect ozone. Stratosphere treated mainly as a boundary layer with little or no physics or chemistry in GCMs.

1970: Papers appear identifying catalytic cycles of oxides of hydrogen, nitrogen as important in ozone production/loss balance.

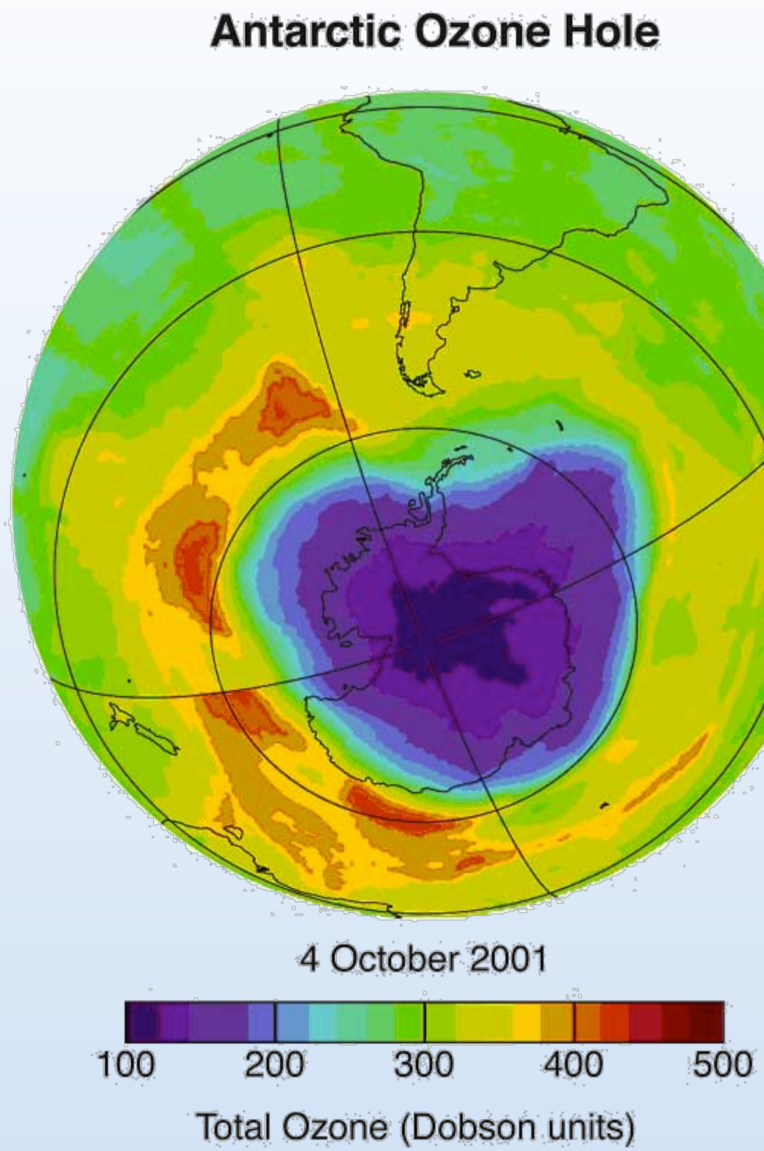
1973: Chlorine incluced as potentially important in catalytic loss of ozone.

1974: Fluorocarbon/Ozone theory published.

1970s-1980s: Models (1D/2D) of stratospheric photochemistry and transport for background atmosphere and potential perturbations.

1987: Montreal Protocol begins regulation of "Ozone-Depleting Substances" (ODS). Subsequent amendments throughout 1990s and 2000s.

Where are we now?



Science: We have more than 35 years of satellite measurements of ozone. Ozone hole was discovered and explained. Key measurements of dozens of short-lived atmospheric molecules that govern stratospheric chemistry. Models have expanded to 3D with interactive dynamics responding to ozone change.

Policy: Montreal Protocol has been signed by ~200 countries. Amendments strengthened its limitation on production of ODS. Chlorine in stratosphere has peaked and begun to decline. Ozone loss has been halted.

Atmospheric Dynamics: Where were we?

By 1963, Smagorinsky, Manabe, and their collaborators had completed a nine-level, hemispheric primitive-equation General Circulation Model.

DEPARTMENT OF COMMERCE
LUTHER H. HODGES, Secretary

WEATHER BUREAU
F. W. REICHELDERFER, Chief

MONTHLY WEATHER REVIEW

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GENERAL CIRCULATION EXPERIMENTS WITH THE PRIMITIVE EQUATIONS

I. THE BASIC EXPERIMENT*

J. SMAGORINSKY

General Circulation Research Laboratory, U.S. Weather Bureau, Washington, D.C.

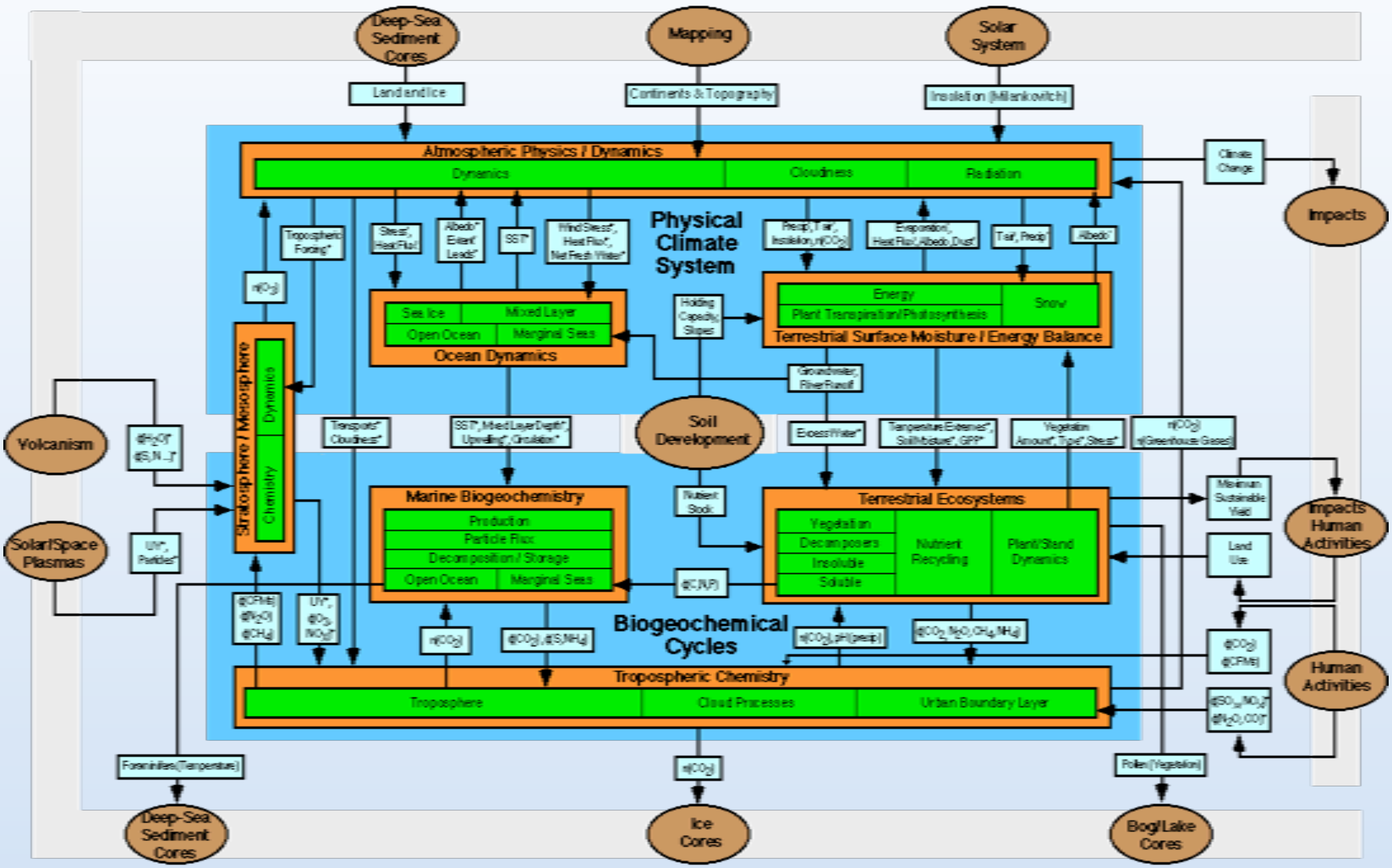
[Manuscript received October 5, 1962; revised January 18, 1963]

1965: Role of composition in dynamics and circulation understood in general. Shortwave heating by ozone, longwave heating/cooling by ozone, CO_2, and H_2O known.   Stratosphere treated mainly as a boundary layer with little or no physics or chemistry in GCMs.

Today: We have very complex, computer-intensive models representing the many interacting sub-systems of the Earth System.

Earth System: Wiring Diagram (ca 1981)

CONCEPTUAL MODEL of Earth System process operating on timescales of decades to centuries

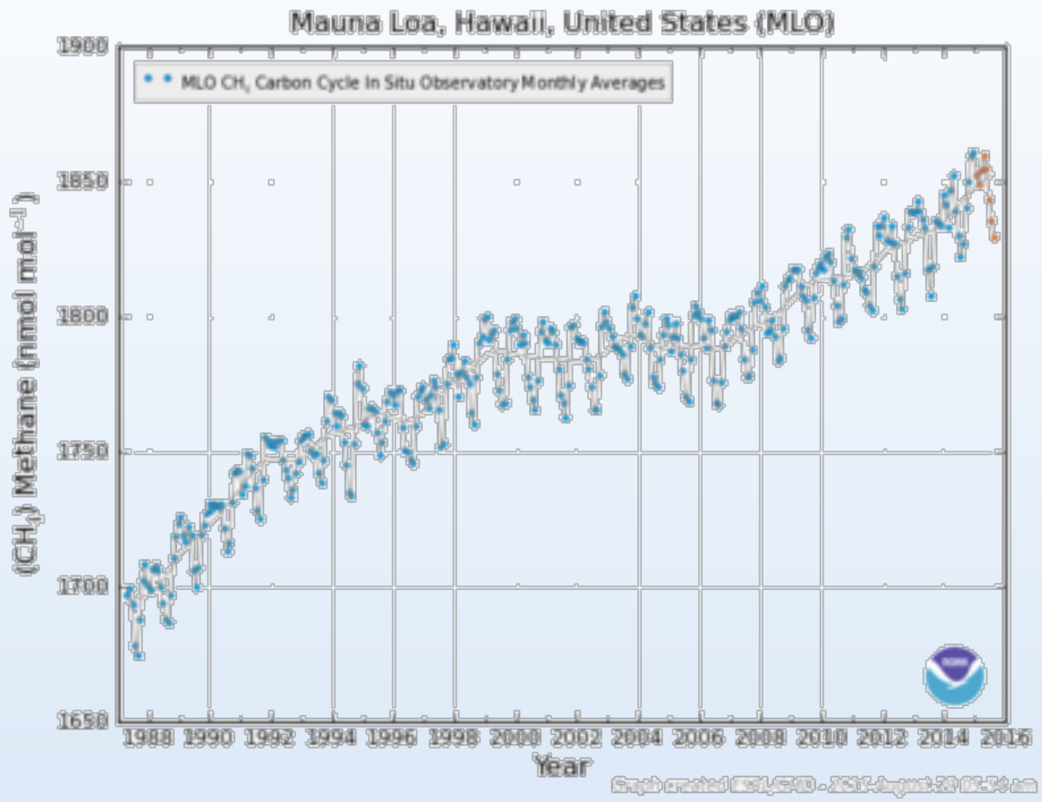


˙ = on timescale of hours to days   * = on timescale of months to seasons   ϕ = flux   n = concentration

Where are we going?

- How do we draw **understanding** from the mountains of output that we can generate with our complex models?
- How do we **test the interactions (feedbacks)** of subsystems in a model? Do we have (all of) the physics correct?
- How do we **design future missions** that will obtain data to critically test how the Earth system will respond to perturbations?

One Example: Methane



- **Will methane increase rapidly with warming of Arctic tundra?**
- **Why did methane not increase during 1998-2008?**