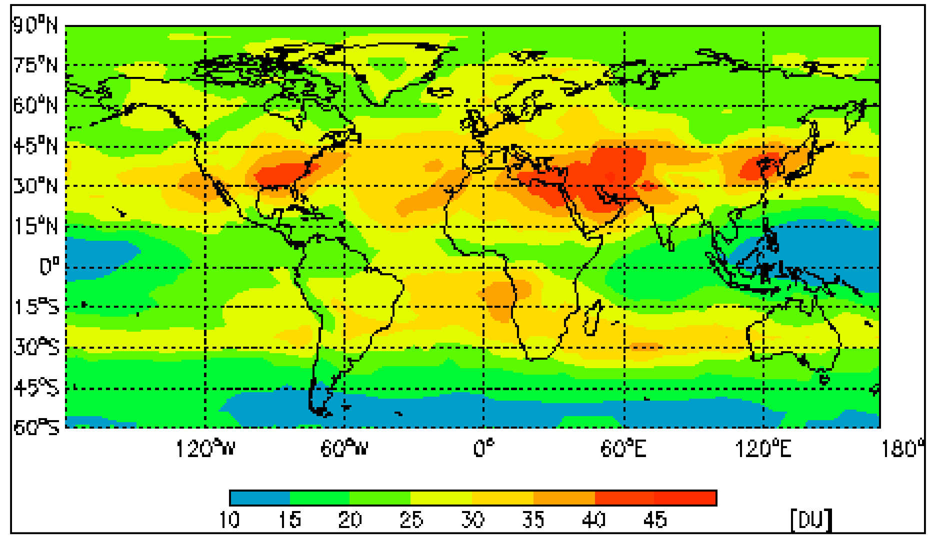
Understanding the Trace Constituent and Particulate Composition of the Earth's Atmosphere and Predicting its Future Evolution

Background and Issues:

- The atmosphere is a “fast integrator” for the Earth, transporting surface emissions quickly around the world (~ week), between hemispheres (~ year), and to high altitudes (~ 3-5 years to 50 km)
- Human activity is significantly changing atmospheric composition in ways that can affect the global, regional, and local environment
- Key Environmental Issues:
  - Global Ozone Depletion and its Impact on Surface UV Radiation
  - Climate Forcing by Radiatively Active Gases and Aerosols
  - Global Air Quality

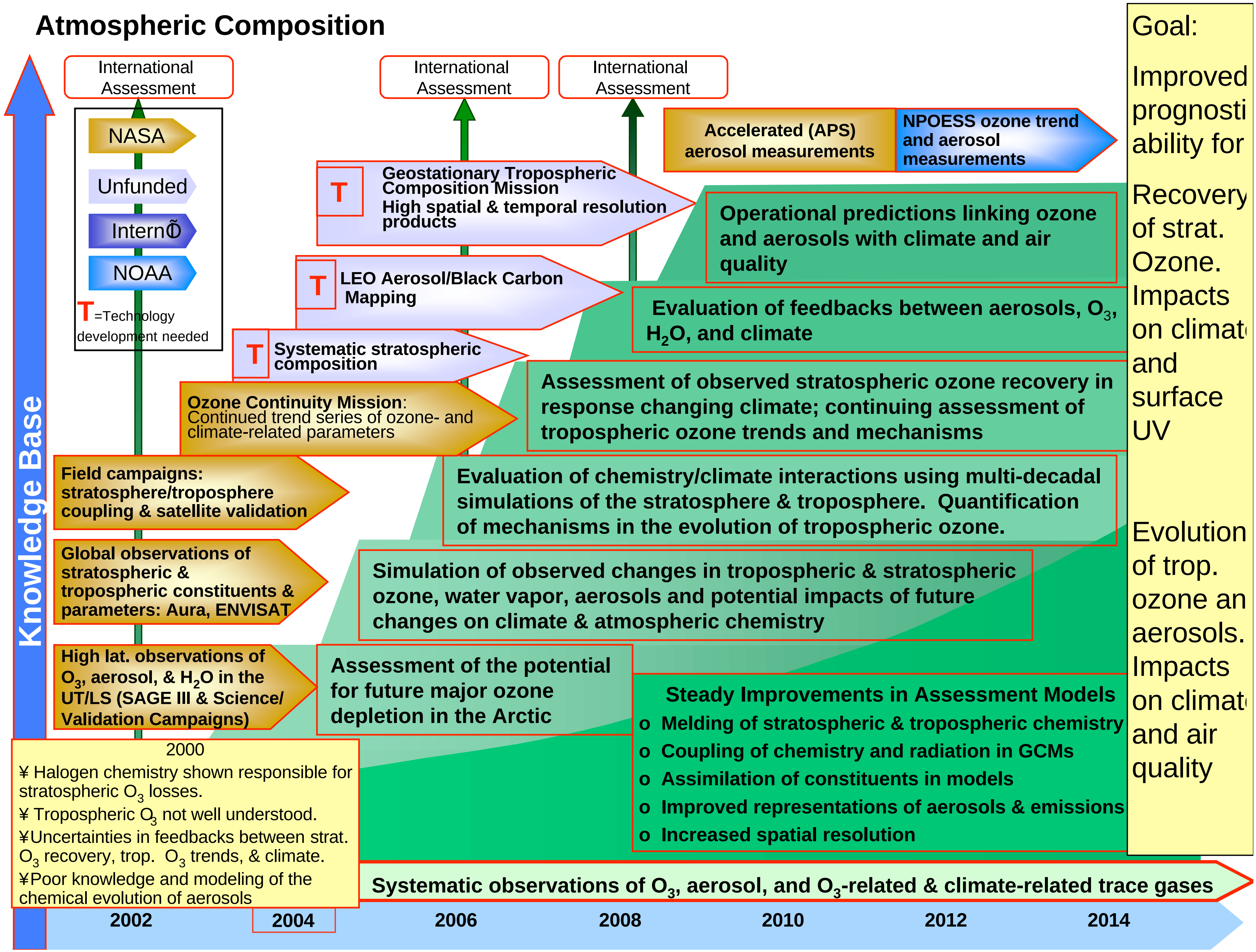


Global model simulation of tropospheric ozone columns

Why NASA?

- Global Observations of Ozone, Aerosols, and Related Trace Gases
- Study of Atmospheric Processes Using Unique Airborne Platform - Sensor Suite Combinatio
- Modeling and Data Assimilation to Provide Atmospheric Data Products and Forecasts
- Note: NASA roles in Research and Monitoring are Called for under Federal Law (NASA Authorization Act, Clean Air Act)

Atmospheric Composition



Anticipated Progress in Answering the Questions:

Roadmap

Where we are now	Where we plan to be
Halogen chemistry largely responsible for stratospheric O_3 loss, but exact % unknown	Quantitative components of O_3 loss (e.g., chemistry vs. dynamics) are understood
Connection between climate change and stratospheric O_3 chemistry recognized but effects on O_3 recovery not well understood	Integrated chemistry and climate models provide improved prognostic ability on the extent and timing of O_3 recovery
Radiatively important change in atmospheric water observed but the temporal variation is not quantitatively understood	Observed changes in atmospheric water are understood and future changes can be predicted
Spatially varying trends in tropospheric O_3 observed but not understood	Geographic evolution of tropospheric O_3 is quantified and understood
Tropospheric O_3 shown to be transported over long distances, but the contributions of such transported O_3 to regional budgets are not understood	The extent of regional pollution that is attributable to the long-range transport of ozone is quantified
Geographical and vertical distribution of atmospheric aerosols are identified but the evolution, composition and properties are not understood	Aerosol evolution, composition, vertical distribution, and radiative impacts are quantified and this information is used in climate models
2002	~ 2015

Anticipated Outcomes and Uses of Results

Roadmap

Result / Capability	Products / Uses for Decision Support
Global ozone time series, variability, and trends quantified at regional spatial resolution. Chemical sources and sinks identified and quantified. Chemistry-climate feedbacks quantified and assessed.	Quantitative global **monitoring & evaluation tools:** (coupled stratosphere/troposphere assessment models) to assess the efficacy of the Montreal Protocol on ozone recovery and to assess effects of climate change on ozone recovery and future atmospheric composition.
Quantification of black carbon/aerosol and greenhouse gas sources and sinks. Quantification of controlling processes and their interactions.	**Maps, data products and information** on relationships among them as input for decision support systems. Simulation models that enable ÒIf É , then ÉÓ scenarios to be explored. **Climate Forecasts**: Projections of changes in carbon, chemical, and aerosol sources and sinks, due to combinations of real-world forcings of global environmental change with sub-regional specificity and good reliability for ~6 mos. to 2 years into the future; and for 50-100 years into the future for a variety of policy-relevant ÒIf É, then ÉÓ scenarios
Global Air Quality: High temporal and spatial resolution composition measurements. Global climate change impacts on regional air quality and the influence of regional air quality on the global climate.	**Air Quality Forecasts**: Linkage of NWP models to air quality models for short-term and seasonal air quality forecasts. Assessment of feedbacks between regional air quality and global climate change.