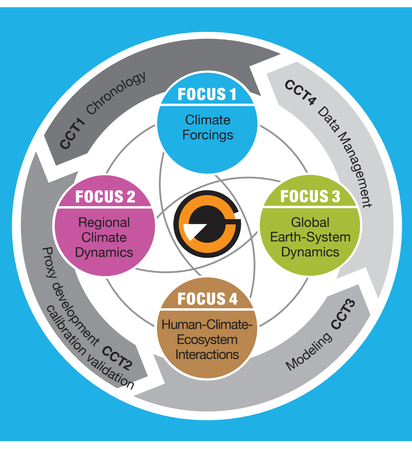
PAGES Focus 1: Climate Forcings

- How did the main climate forcing factors vary in the past?
- How sensitive was (and is) the climate system to these forcings?
- What caused the natural greenhouse gas and aerosol variations?
- Can paleodata constrain climate sensitivity and the carbon cycle-climate feedback?
- In what precise sequence and over what timescales did changes in forcings, climate and ecological systems occur?



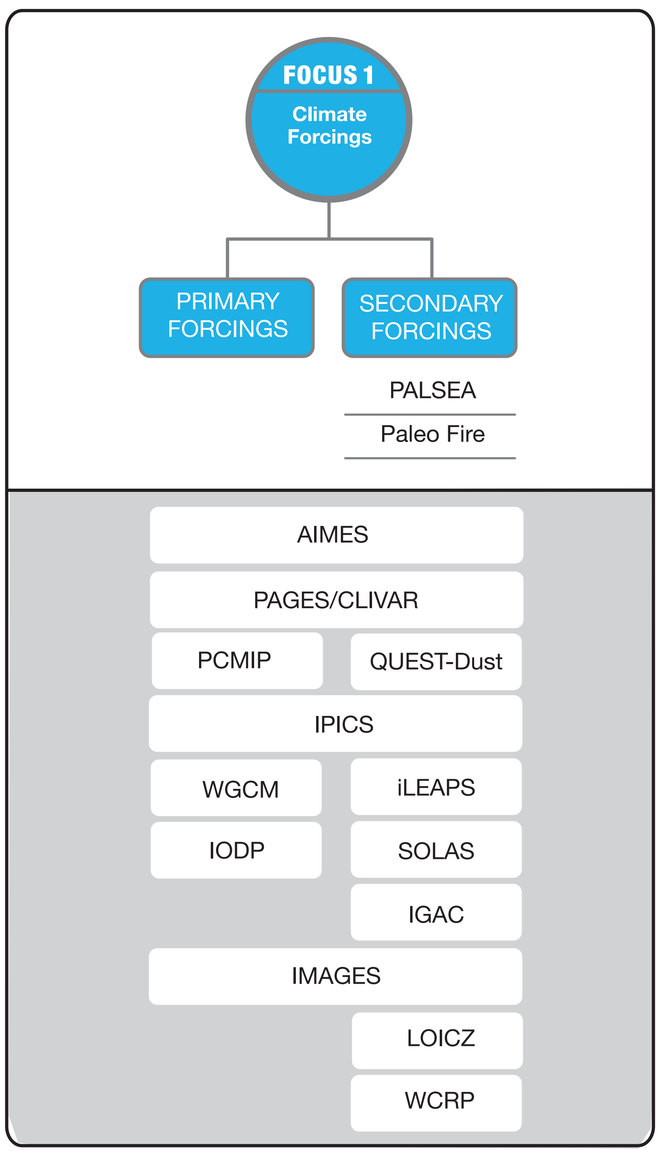
Aims

Focus 1 fosters activities that aim to produce improved, extended, and consistent timeseries of climate forcing parameters, both natural and anthropogenic, including solar insolation and irradiance intensity, volcanic activity, land cover, sea ice, and greenhouse gas and aerosol concentrations. Furthermore, Focus 1 aims to quantitatively understand the causes and impacts of variations in climate forcings, including climate sensitivity and the carbon cycle-climate feedback.

Rationale

Climate forcings are imposed radiative perturbations of the Earth's energy balance and can be of natural or anthropogenic origin. The sensitivity of the climate system to an imposed forcing is dependent not only on the magnitude and character of the climate forcing but also on the feedbacks within the climate system, which amplify or diminish the responses. "Primary" climate forcings are those that are externally imposed on the climate system and do not result from natural feedback processes in the Earth System. Orbital solar insolation, irradiance intensity and volcanic aerosols are therefore classified as primary forcings. "Secondary", natural climate forcings include those induced by mineral dust, greenhouse gases, land cover, sea ice, continental ice, glacial meltwater, and sea level.

Structure



Structure of Focus 1. Top: Focus Themes (blue boxes) with the corresponding Working Groups below. Bottom: Overlap with external programs (white boxes).

Activities & Goals

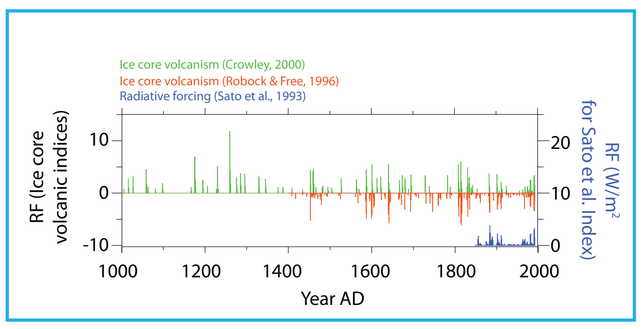
Goals by Theme:

PRIMARY FORCINGS

- Orbital Solar Insolation – To tie together the timing of insolation changes and of climatic and environmental responses. To unravel how the geometric, spatial and seasonal components of orbital insolation changes affected the Earth System.

- Solar Irradiance – To improve documentation and understanding of solar irradiance variations. This necessitates progress in understanding of irradiance proxies, such as sunspot numbers and cosmogenic signatures in ice cores and tree rings, and that solar and non-solar influences are disentangled. The ultimate goals are to extend the low-frequency solar-forcing record back through the entire Holocene, to retrieve more detailed and spatially distributed records of cosmogenic isotopes, and to interpret them in association with modeling of the mechanisms affecting the isotope concentration in ice and marine sediments.

- Volcanic Aerosols – To establish dates, latitude, magnitude and radiative impact of explosive volcanic eruptions through correlation of additional ice core records and the development of new tracers, such as the identification of stratospheric eruptions through studies of isotopes in sulfate. The ultimate goal is to extend the detailed record of volcanic forcing through the entire Holocene.

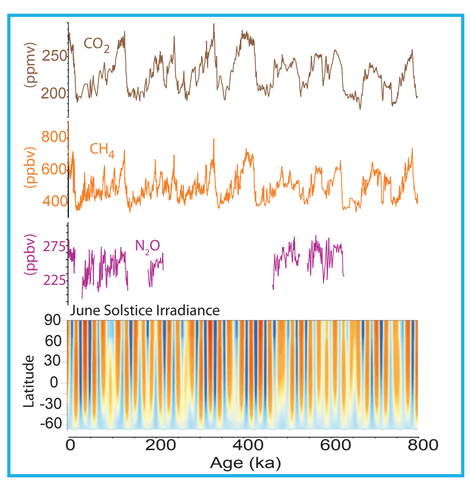


Radiative forcing (RF) inferred from three reconstructions of volcanism for the last 1 ka. Blue and green lines have been multiplied by -1 for display purposes (figure modified from Crowley, 2000).

SECONDARY FORCINGS

- Mineral Dust – To better understand dust loading at a variety of sites—high and low latitudes, continental and oceanic—in order to better constrain the temporal and spatial character of mineral aerosol forcing over glacial-interglacial cycles, and to unravel past atmospheric dynamics.

- Greenhouse Gases – To improve the record of atmospheric N_2O variations and the temporal resolution of the CO_2 records. To better constrain the phasing between insolation, greenhouse gas concentrations and climate-environment responses during climate transitions. To improve understanding of the causes of natural fluctuations in greenhouse gases, and to combine greenhouse gas and temperature reconstructions to constrain the carbon cycle-climate feedback, i.e., the sensitivity of atmospheric CO_2 to a change in climate.



Timeseries representing the variability in greenhouse gases and June solstice irradiance over the last 800 ka; red and blue indicate high and low solstice irradiance, respectively (Wolff et al., 2006; Laskar et al., 2004).

- Land Cover – To obtain better records and understanding of regional changes in land use and land cover through vegetation reconstructions and indirect evidence, such as paleofire activity, denudation and soil erosion rates.

- Sea Ice – To improve seasonal reconstructions of past changes in sea ice cover for a better quantification of the albedo and ocean-atmosphere gas exchange of the high-latitude oceans and to understand regional climate dynamics.

- Continental Ice and Sea Level – To improve reconstruction of the extension, geometry and volume of past ice sheets and their freshwater discharges to surrounding oceans, and to produce a master sea-level curve for the last glacial-interglacial cycles.

Implementation

The Primary Forcings Theme does not yet have a formal Working Group (WG). To unify the international research effort, Focus 1 will organise a number of activities, with initial emphasis on: 1) Development of high-resolution records of solar and volcanic activity and ensuring availability of the datasets to modelers, 2) Understanding cosmogenic isotopes and associated modeling of the different mechanisms that affect their concentration in ice and marine sediments as a measure of solar activity, and 3) Development of key primary forcing curves that can be used by all modeling groups.

The Secondary Forcings Theme has several WGs established. The Palaeofire WG was formed together with the AIMES and iLEAPS IGBP programs. The Paleo-Constraints on Sea Level Rise (PALSEA) WG is planning a comprehensive overview of sea level projection from a paleo-perspective. The Past Atmospheric Dynamics (ADOM) WG, which is mainly affiliated with Focus 3 under the Rapid Climate Change Theme, will study eolian records from ice, terrestrial and marine archives to reconstruct dustiness and atmospheric circulation patterns over the last glacial cycle.