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Feedbacks between vegetation and precipitation inferred from remote sensing

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The strength of the local feedback between the land surface and the atmosphere varies spatially across the Earth's surface. Here, we use data-driven estimates of precipitation and vegetation to derive quantitative global measures of this feedback.

The data consist of monthly global values for the years 1982 - 2000 at a spatial resolution of 0.5 degrees. Since the focus is on local feedbacks, each pixel is analysed independently. The precipitation P_t in month t is derived from CRU data, while satellite-derived values of the Normalized Difference Vegetation Index (NDVI - a measure of greenness) are used as a proxy for the corresponding 'photosynthetic capacity' N_t.

Following subtraction of the the seasonal cycle to give residuals p_t and n_t, a bivariate autoregressive statistical model is fitted as follows:

$$\begin{pmatrix} p_t \\ n_t \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} p_{t-1} \\ n_{t-1} \end{pmatrix} + \begin{pmatrix} \epsilon_t \\ \eta_t \end{pmatrix}$$

(Here ϵ_t and η_t represent 'random noise' due to unresolved climatic processes.) For each pixel, the fitted constants a, b, c and d quantify the extent to which last month's state anomaly (p_{t-1}, n_{t-1}) is useful statistically as a predictor of this month's state anomaly (p_t, n_t). The statistical significance of non-zero values for the feedback terms b and c is assessed using the 'Granger causality' formalism.

We present global maps of 'feedback strength' based on our analysis and discuss the physical mechanisms responsible.