TEMPORAL VARIABILITY OF OBSERVED AND SIMULATED HYPERSONTAL EARTH REFLECTANCE

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CLARREO
Climate Absolute Radiance and Refractivity Observatory

- CLARREO Objectives
  - High accuracy and ability to monitor that accuracy on orbit
  - Sufficient information content
  - Sensitivity to detect long-term trends

- CLARREO Measurement Requirements needed to address
  - How do climate models reproduce the variability observed in the Earth’s climate system?
  - How well do climate models reproduce the variability observed in the Earth’s climate system?

- CLARREO Science Questions
  - Between the two emission scenarios, the PCs overlap
  - How well do climate models reproduce the variability observed in the Earth’s climate system?
  - How do reflected solar radiation measurements change over space, time, and wavelength in response to changes in Earth’s climate?

SCIAMACHY and OSSE Decadal Variability

- The first four PCs calculated from SCIAMACHY and OSSE reflectance (All Sky, Constant Concentration and A2 Emission Scenarios) between 2002 and 2010.
- The spectral shape of the first and second PCs compare well between SCIA and OSSE, but the spectral shapes of the other PCs differ, implying that they are different variables.
- Between the two emission scenarios, the PCs overlap – the nearly-decadal variability of the reflectance spectra simulated from both cases essentially identical.

COMPARING OBSERVED AND MODELED VARIABILITY

- The first four transformed SCIAMACHY and OSSE eigenvectors, calculated using the subspace intersection (items 1 and 3 from the flow chart), have high correlations, implying similar spectral shapes.
- The original PC scores calculated from the PCA of SCIAMACHY and OSSE reflectance spectra were projected onto these transformed eigenvectors to determine the corresponding scores.

SCIAMACHY Tropics PC1
- NH: 0°-30°N
- SH: 0°-30°S
- Spectral shapes of SCIA and OSSE PC1 are similar in the NH and SH.

OSSE A2 Tropics PC1
- Spectral shapes of SCIA and OSSE A2 PC1 are similar in the NH and SH.
- Tropics bands and allows for comparison of their PC1 time series.

OSSE A2 Tropics PC2
- The first four transformed OSSE and SCIAMACHY eigenvectors, calculated using the subspace intersection (items 1 and 3 from the flow chart), have high correlations, implying similar spectral shapes.
- The original PC scores calculated from the PCA of SCIAMACHY and OSSE reflectance spectra were projected onto these transformed eigenvectors to determine the corresponding scores.

0°-30°N and 0°-30°S Transformed Eigenvectors

- The first transformed OSSE and SCIAMACHY eigenvectors, calculated using the subspace intersection (items 1 and 3 from the flow chart), have high correlations, implying similar spectral shapes.
- The original PC scores calculated from the PCA of SCIAMACHY and OSSE reflectance spectra were projected onto these transformed eigenvectors to determine the corresponding scores.

Temporal Variability Comparison Summary

- Annual and seasonal patterns of physical variables observed in nearly-decadal observed temporal variability - e.g., ITCZ location
- Hyperspectral reflectance contains information about the temporal variability of Earth’s climate system.
- Observed temporal variability can be used to evaluate how well model reproduces temporal variability of climate system.

Decadal Variability Summary

- Observed and Simulated Reflectance
  - Spectral Resolution/Smoothing: 15 nm FWHM / 3 mn Spatial Sampling: Averaged in 30° latitude bands Temporal Sampling: Land and ocean monthly averaged reflectance spectra
- SCIAMACHY: 2002 – 2010
- OSSE: 2000 – 2099

- Experiment Setup
  - Idealized spectral decomposition
- Each PC is a linear combination of spectral reflectances.
- One PC typically explains more than one physical variable, often making each component difficult to physically interpret.
- Graphically: Each PC represents a new orthogonal axis that explains the remaining variance not explained by previous components.
- Scores – the weight that data points have relative to each PC (Black dots projected onto each blue line.)

OSSE Centennial Variability

- PCs calculated by including all spectral reflectance spectra averaged in the 0°-30° latitude band between 2000 and 2099 for both emission scenarios.
- In contrast to the comparison of the nearly decadal PCs, the centennial variability between the two scenarios differs.

- The constant concentration PC time series do not exhibit secular trends, as expected; however, the A2 PC time series do exhibit secular trends throughout the century, based on the simulation input variables.

Centennial Variability Summary

- Centennial variability of forced simulation modeled reflectance exhibits secular trends of physical variables – e.g., Aerosol optical depth and water vapor
- By quantifying the OSSE centennial variability, this method demonstrates its utility in studying changes to the Earth’s climate system and linking changes to physical variables.

SCIAMACHY hyperspectral reflectances are the best operational example of CLARREO-like reflectance spectra

Native Spectral Resolution: 0.24 - 1.5 nm
Nadir Spatial Resolution: 30 km (along-track) / 60 km (cross-track)
Radiometric Accuracy: Sun-normalized: 2-3%