

Supplementary material

1. Details of the Mixed Sample Generation Process

A total of 20,000 mixed NDPI curves ($NDPI_{mix}$) were simulated using Equation (13) for a three-endmember mixture. In Equation (13), $f_{nonwheat1}$ and $f_{nonwheat2}$ are the fractions of the two nonwheat endmembers and $NDPI_{nonwheat1}$ and $NDPI_{nonwheat2}$ are the NDPI curves of the two nonwheat endmembers. f_{wheat} was generated 20,000 times with a random number generator from a uniform distribution (0–1). $f_{nonwheat1}$ and $f_{nonwheat2}$ were generated by dividing $(1-f_{wheat})$ randomly by a uniformly distributed number c :

$$\begin{cases} f_{nonwheat1} = c(1 - f_{wheat}) \\ f_{nonwheat2} = (1 - c)(1 - f_{wheat}) \end{cases} \quad (S1)$$

$NDPI_{wheat}$ was randomly selected from the 10 winter wheat endmembers, and $NDPI_{nonwheat1}$ and $NDPI_{nonwheat2}$ were randomly selected from the 70 nonwheat endmembers. Thus, 20,000 mixed NDPI curves were simulated in total, among which 10,000 were positive samples ($f_{wheat} > 50\%$) and the other 10,000 were negative samples ($f_{wheat} < 50\%$).

2. Details of the Simulation of NDPI Curves with Cloud Contamination

In the cloud contamination simulation experiment, a random cloud distribution model was considered because such models cover most of cloudy scenarios:

$$\begin{aligned} &0 < f_{cloud} < 100\%, \quad 0 < f_{cloud\ key} < f_{key}, \quad 0 < f_{cloud\ nonkey} < f_{nonkey} \\ &\text{subject to } f_{cloud\ key} + f_{cloud\ nonkey} = f_{cloud}, \quad f_{key} + f_{nonkey} = 1 \end{aligned} \quad (S2)$$

where f_{cloud} is the fraction of cloudy observations in the NDPI curves during the entire winter wheat growing season; $f_{cloud\ key}$ and $f_{cloud\ nonkey}$ are the fractions of cloud observations in the key and nonkey phenological stages, respectively; and f_{key} and f_{nonkey} are the fractions of the entire winter wheat growing season contributed by the key and nonkey stages, respectively. f_{cloud} was generated from 0% to 100% in 10% increments, and $f_{cloud\ key}$ and $f_{cloud\ nonkey}$ were generated following the rules in Equation (S2), also in 10% increments. In total, 2,390,953 cloudy NDPI curves were simulated, among which 1,062,923 curves are winter wheat and the other 1,328,030 are non winter wheat.