The Crude Sanctioned Refinery Disruption Event Detector. Satellite Thermal Plus AIS Tanker Arrivals Against WTI Forward Returns.

Why satellite thermal detection and AIS tanker arrivals together reveal real supply disruption at Iran and Venezuela refineries that neither feed catches alone. Why the signal delivers plus 0.34pp Disruption-state edge and minus 1.62pp Normalizing-state edge across 2,822 trading days. How to use a sparse geopolitical-event detector in the six-signal crude stack.

David Stendahl · Market Lab Analytics · November 4, 2026

What this signal is

Sanctioned-country refineries do not publish operational data. Iran, Venezuela, and post-2022 Russia represent roughly 8-12 percent of global refining capacity. When they fail, global product supply tightens and crude demand rises as other refiners run harder to meet the gap. The signal reveals these disruptions through two independent satellite data streams. NASA FIRMS thermal anomaly feeds catch refinery fires in near-real-time via infrared imagery. AIS tanker arrival data catches loading drops via maritime vessel tracking.

The CONJUNCTION distinguishes real supply disruption from noise. A fire ABOVE baseline AND arrivals BELOW baseline on the same day is a real event. A fire alone can be routine flaring. A loading drop alone can be reporting lag. Both together force a reclassification. Iran contributes roughly 31 events in the last 90 days with a mean arrivals drop of minus 67 percent and a maximum fire radiative power of 1672 megawatts. Venezuela contributes roughly 31 events with mean drop minus 58 percent and maximum FRP 2505 megawatts.

Current reading as of November 3, 2026: composite plus 0.254, Neutral, 1 trading day in band. No active disruption firing today.

State-conditional edges are monotonic on point estimate. Disruption (state plus one, composite above plus 0.3) covers 12.0 percent of the sample, delivering plus 4.01 percent per-day forward sixty-day, an edge of plus 0.34 percentage points above the plus 3.67 percent baseline. Neutral covers 74.3 percent, delivering plus 3.91 percent (edge plus 0.24pp). Normalizing (state minus one, composite below minus 0.3) covers 13.6 percent, delivering plus 2.05 percent (edge minus 1.62pp).

The signal is a SPARSE EVENT DETECTOR. Most days sit in Neutral. State firings come in short 2-5 session windows during real-world sanctions escalations, war events, or internal unrest in sanctioned countries.

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How the conjunction detector composes

Feed one: NASA FIRMS thermal anomaly data. Satellites (VIIRS and MODIS) detect infrared heat signatures from refinery flare stacks and process units. Near-real-time with 6-12 hour latency. For each sanctioned-country refinery, the signal tracks fire radiative power (FRP, megawatts) and flags days when FRP exceeds the refinery's 30-day baseline.

Feed two: AIS maritime tanker arrival data. The maritime derivatives pipeline tracks vessel AIS transponders and identifies tanker arrivals at refinery coordinates. For each sanctioned-country refinery, the signal tracks arrival counts and flags days when arrivals fall below the refinery's 30-day baseline.

The CONJUNCTION logic. A refinery flags an event on a day if BOTH conditions fire. Fire above baseline alone could be routine flaring. Arrivals drop alone could be seasonal slowdown. Both together indicate a REAL disruption.

Severity weighting. Each flagged event is weighted by severity = FRP megawatts times absolute arrivals-delta-percent. A 2500 MW fire with a 70 percent arrivals drop scores higher than a 500 MW fire with a 20 percent drop. This concentrates the signal on the biggest, most-disruptive events.

Daily aggregate. For each trading day, the signal sums the severity score across all sanctioned-country refineries (currently Iran, Venezuela, and post-2022 Russia). The aggregate is z-scored on a 90-day rolling window (short due to limited historical satellite-plus-AIS data; will extend to 252d as history accumulates). AR(1)-reduced to strip autocorrelation persistence. Tanh-bounded.

The state machine fires state plus one above plus 0.3 (Disruption), zero between minus 0.3 and plus 0.3 (Neutral), minus one below minus 0.3 (Normalizing).

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What the state-conditional returns have actually done

> **Reference baseline, WTI crude fwd 60-day unconditional over live window**
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> WTI crude ratio-adjusted continuous forward-sixty-day return baseline over the live-signal window of 2015 through 2026-11-03: mean plus 3.67 percent, median plus 2.58 percent, standard deviation 20.86 percent. Sample 2,822 trading days. The live window is shorter than most signals because the AIS maritime pipeline data only has reliable sanctioned-country refinery coverage starting around 2015.

Disruption (composite above plus 0.3). 338 trading days, 12.0 percent of the sample. Per-day mean forward sixty-day plus 4.01 percent, edge plus 0.34 percentage points above baseline. The disruption state fires when sanctioned-country refineries show real fire-plus-loading-drop conjunctions. The edge is modest on average because the per-day metric averages across the firing day plus the forward 60 days that include post-event normalization.

Neutral (composite between minus 0.3 and plus 0.3). 2,097 trading days, 74.3 percent of the sample. Per-day mean forward sixty-day plus 3.91 percent, edge plus 0.24 percentage points above baseline. The middle state is the modal regime. No active disruption firing. The signal is a SPARSE EVENT DETECTOR so most days are in Neutral.

Normalizing (composite below minus 0.3). 383 trading days, 13.6 percent of the sample. Per-day mean forward sixty-day plus 2.05 percent, edge minus 1.62 percentage points below baseline. The normalizing state fires when sanctioned-country refineries show arrivals recovery combined with fire below baseline. This often coincides with demand collapses (when global demand drops, sanctioned refineries can rebuild throughput). The 2020 COVID window is the archetype.

The spread is 1.96 percentage points from the Normalizing tail to the Disruption tail. The bearish tail is bigger than the bullish tail on point estimate, which matches the event-driven nature of the signal.

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Three cases that frame how to read this signal

Case 1: March 2022. The Ukraine invasion and Russia sanctioned-refinery event cluster.

The composite moved into state Disruption on March 16, 2022 as sanctioned-country refineries (primarily Russia, newly-sanctioned) showed fire-and-loading-drop conjunctions in the days after the invasion-week sanctions wave. Multiple Russian Black Sea and Baltic refineries recorded fire events above baseline while AIS tanker arrivals cratered. The signal fired for 5 consecutive trading sessions. Over the window WTI ratio-adjusted continuous ran from 56.1 to 65.5, a plus 16.8 percent move. The 2022 case is the canonical geopolitical-event firing. The signal caught the sanctioned-refinery disruption on the DAY the sanctions started biting, inside a week of the invasion.

Case 2: December 2018. The Iran sanctions re-imposition pulse.

The composite moved into state Disruption on December 24, 2018 as Iranian refineries showed fire-and-loading-drop conjunctions following the November 2018 Iran sanctions re-imposition. Iranian loading dropped sharply as US secondary sanctions pulled tanker operators out of Persian Gulf routes. The signal fired for 2 consecutive trading sessions. Over the window WTI ratio-adjusted continuous ran from 33.9 to 36.8, a plus 8.7 percent move. The 2018 case illustrates the signal catching a sanctioned-country supply shock weeks AFTER the formal sanctions date, as the real-world loading response lagged the policy announcement.

Case 3: April 2020. The COVID-era sanctioned-refinery normalizing pulse.

The composite moved into state Normalizing on April 17, 2020 as sanctioned-country refineries recovered throughput briefly during the COVID demand collapse. Iranian and Venezuelan refineries saw tanker-arrival rebounds as global demand cratered and stock-levels inverted. The signal fired for 2 consecutive trading sessions. Over the window WTI ratio-adjusted continuous fell from 14.5 to 11.8, a minus 18.4 percent move. The 2020 case illustrates how the signal catches NORMALIZING firings during demand collapses when the usual supply-constraint story reverses.

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How to use the signal today

As of November 3, 2026, the composite reads plus 0.254 in the Neutral band. No active fire-plus-loading-drop conjunction firing from Iran or Venezuela today. The signal is a SPARSE EVENT DETECTOR, so Neutral is the modal regime (74.3 percent of days).

The practical rule. Watch the daily satellite and AIS feed refresh for new event spikes. State plus one firings come in short 2-5 session windows after real-world sanctions escalations, war events, or internal unrest in sanctioned countries. When the signal fires, the bullish-crude bid is EVENT-DRIVEN not headline-driven. The satellite thermal detection catches the physical fire before news sources confirm it. The AIS arrival data catches the operational-response lag.

Pair with the broader Z12627 supply-shock composite to distinguish specific sanctioned-country events from generic cross-channel supply pressure. When both fire simultaneously, the stacked bullish-supply read is maximally clean. When the supply-shock composite fires but this signal does not, the supply pressure is coming from drilling or hurricanes or ETF flow, not from sanctioned-country disruption.

Two triggers. First, the composite crosses above plus 0.3 (state Disruption). That requires an Iran or Venezuela refinery (or a sanctioned Russian refinery) to show a fire above baseline AND arrivals below baseline on the same day. Second, the composite drops below minus 0.3 (state Normalizing). That signals sanctioned refineries recovering throughput, bearish-crude on easing supply constraint.

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Methodology notes

Data sources. NASA FIRMS thermal anomaly feed filtered to sanctioned-country refinery coordinates. Near-real-time via VIIRS and MODIS satellite instruments with 6-12 hour latency. Maritime derivatives pipeline AIS tanker arrival data (REFINERY_FIRE_LOADING_LINK table, built 2026-06-07). Target benchmark NYMEX WTI ratio-adjusted continuous (CL21160RD from CSI).

Signal construction. Daily event aggregate. For each sanctioned-country refinery check if fire radiative power is above 30-day baseline AND arrivals are below 30-day baseline on the same day. Where both fire, severity is FRP_MW times absolute arrivals-delta-percent. Daily aggregate is the sum across all sanctioned refineries. Z-scored on 90-day rolling window. AR(1)-reduced. Tanh-bounded.

Validation. The signal is a sparse event detector (fires state plus or minus one roughly 25 percent of days total, with Neutral the modal regime at 74 percent). Daily IC is diluted by the modal Neutral days. State-conditional per-day means capture the event-day effect. Disruption plus 4.01 percent (edge plus 0.34pp), Neutral plus 3.91 percent (edge plus 0.24pp), Normalizing plus 2.05 percent (edge minus 1.62pp).

Benchmark construction. WTI crude 60-day forward return computed as close.pct_change() from the CL21160RD ratio-adjusted continuous CSI file, rolled over 63 trading days and shifted forward.

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What this signal does not cover

Blind spots a PM cares about before sizing

First, the short historical satellite-plus-AIS record. The maritime derivatives pipeline only has reliable sanctioned-country refinery coverage starting around 2015. The 2,822-day live window is much shorter than most crude signals in the library. A PM should budget for the possibility that the 2015-2026 window is unrepresentative of the full historical regime.

Second, the 90-day z-score window is unusually short. Most signals use 252 days or longer. The short window was chosen because the FIRMS-plus-AIS data history is limited. As history accumulates, the window will extend to 252 days. Until then, the signal is more sensitive to recent-regime noise than a long-window signal would be.

Third, false-positive risk from routine flaring. Not every fire above baseline is a real disruption. Refineries flare routinely during process adjustments, maintenance events, and seasonal demand shifts. The AIS arrivals filter reduces false positives (only flag days where BOTH fire and arrivals-drop fire) but the filter is imperfect. In high-flaring periods (summer gasoline demand, winter heating-oil demand) the signal can misfire.

Fourth, the sanctioned-country list evolves over time. Iran and Venezuela have been sanctioned for years. Russia was added in 2022. Other countries may be added or removed as geopolitical regimes shift. A PM should check whether the current firing is from one of the long-sanctioned countries (Iran/Venezuela, structural) or from a newly-sanctioned country (Russia, episodic).

This research brief is for informational purposes only and does not constitute investment advice. Past performance is not indicative of future results. State-conditional statistics are computed through 2026-11-03 against NYMEX WTI ratio-adjusted continuous. The short satellite record, 90-day z-score window, false-positive risk, and sanctioned-country list evolution are explicitly disclosed. Data sources: NASA FIRMS thermal feed, maritime derivatives pipeline AIS, CSI CL21160RD. Internal Phase 0 audit dated 2026-11-04.