Spatiotemporal Pattern of Gypsum Blooms in the Salton Sea, California, during 2000-2018

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Introduction

1) Gypsum blooms and the resulting incidents of water quality deterioration have threatened the environmental health of Salton Sea.
2) Monitoring temporal and spatial changes in gypsum blooms suffered no long time-series data covering the entire domain with high temporal frequency.
3) Satellite remote sensing provides long-term and high frequency data; however, optical properties are lacking.
4) In this study, we developed an algorithm suitable to monitor gypsum blooms in the Salton Sea using MODIS data, examined the spatial and temporal distribution of gypsum blooms during 2000–2018, and analyzed the driving forces.

Data Sources

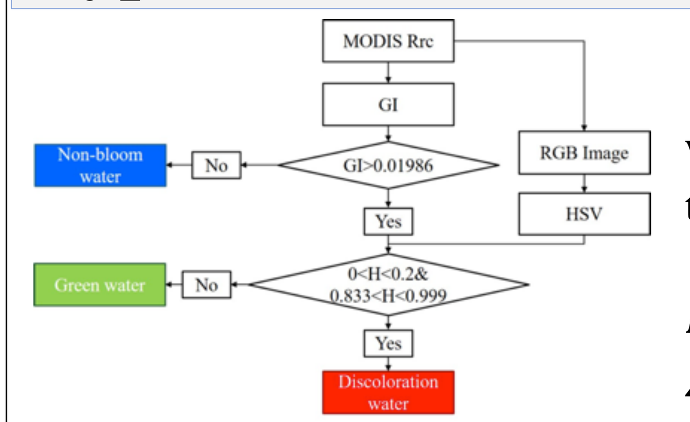
MODIS data:

- Specific data source: MODIS/Terra Level-1A data
- Time series: February 2000 - December 2018
- Band and resolution: 645 and 859 nm (250 m); 469, 555, 1240, 1640, and 2130 nm (500 m)

Landsat data:

- Specific data source: Landsat Thematic Mapper (TM)/Enhanced TM plus (ETM+)/Operational Land Imager (OLI)
- Time series: 2000 - 2018
- Number of scenes: 209

Gypsum Bloom Index (GI)



$GI = R_{rc,Green} - R'_{rc,green}$

where $R'_{rc,green}$ is the baseline R_{rc} at the green light band (555 nm),

$R'_{rc,green} = R_{rc,blue} + (R_{rc,NIR} - R_{rc,blue}) \times (\lambda_{green} - \lambda_{blue}) / (\lambda_{NIR} - \lambda_{blue})$

$R_{rc,Green}$, $R_{rc,blue}$, and $R_{rc,NIR}$ are the Raleigh-corrected reflectance of green (555 nm), blue (469 nm), and short-wave infrared (859 nm) band , respectively.

λ_{green}, λ_{blue}, and λ_{NIR} are the central wavelength of the MODIS spectral band for green (555 nm), blue (469 nm), and short-wave infrared (8599 nm) band , respectively.

Application and Validation of Gypsum Bloom Index (GI)

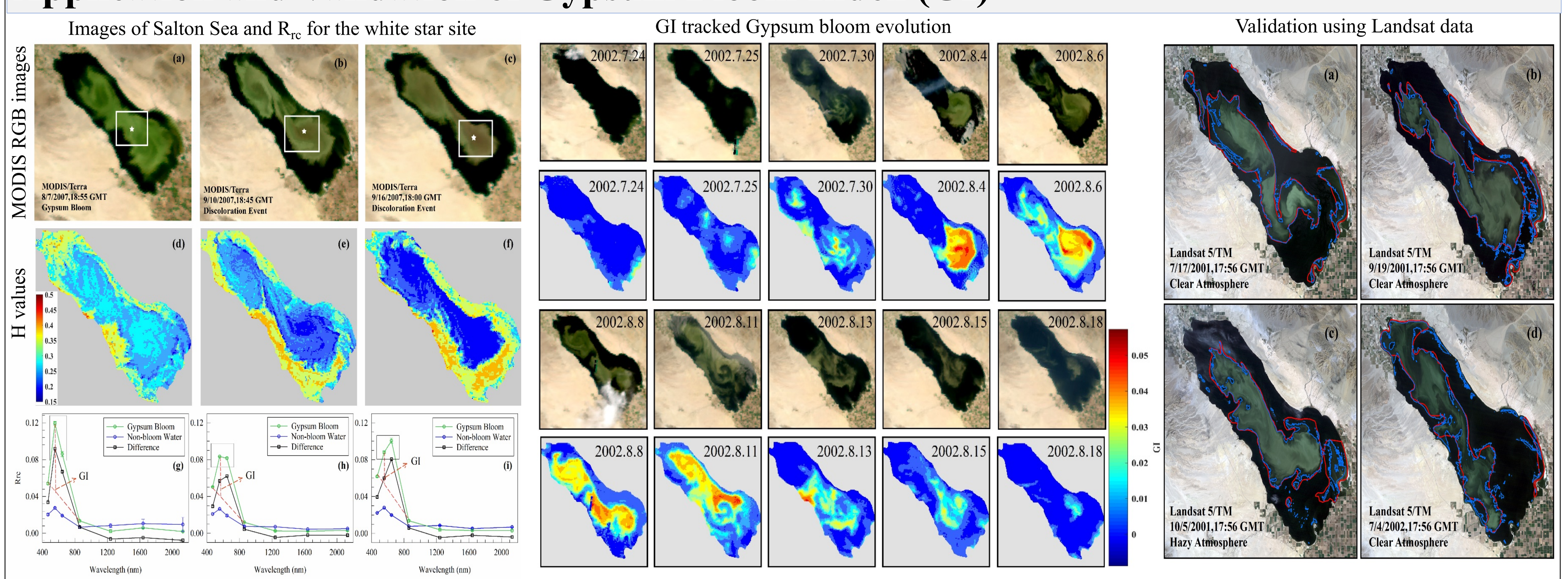


Fig.1 The application of GI in gypsum bloom event in the Salton Sea and the validation of gypsum bloom area using Landsat data.

The figure shows that GI, constructed based on MODIS R_{rc} data of the 469, 555 and 859 nm bands, can used to map gypsum bloom areas over long term and across large area.

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Spatiotemporal Distribution of Bloom Events

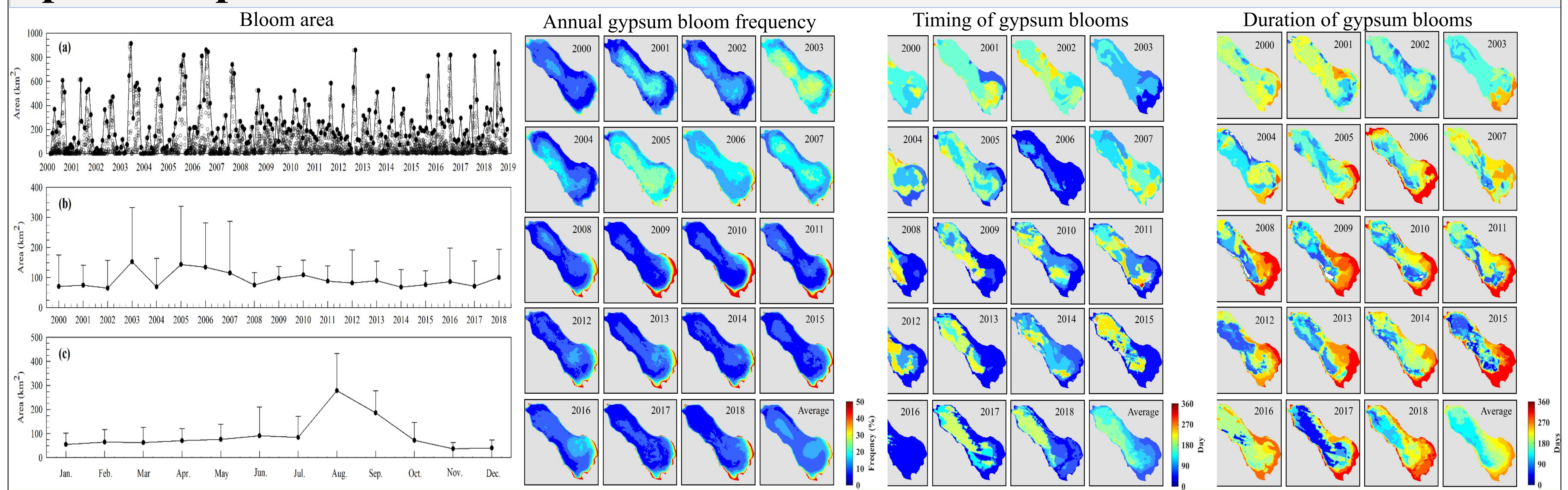

Fig. 2 The bloom area and the spatiotemporal distribution of bloom events in Salton Sea during 2000-2018.

The years of 2005, 2006, 2016 and 2018 experienced the highest frequency of severe gypsum bloom events (>40), and the months of August and September featured the largest monthly average gypsum bloom. Spatially, southeastern shore, followed by southern and northern central regions, suffered from the most frequent gypsum blooms during 2000–2018, but the southeastern shore of the lake had longest duration (blooming started earlier and ended later).

Driving Factors of Gypsum Bloom Events

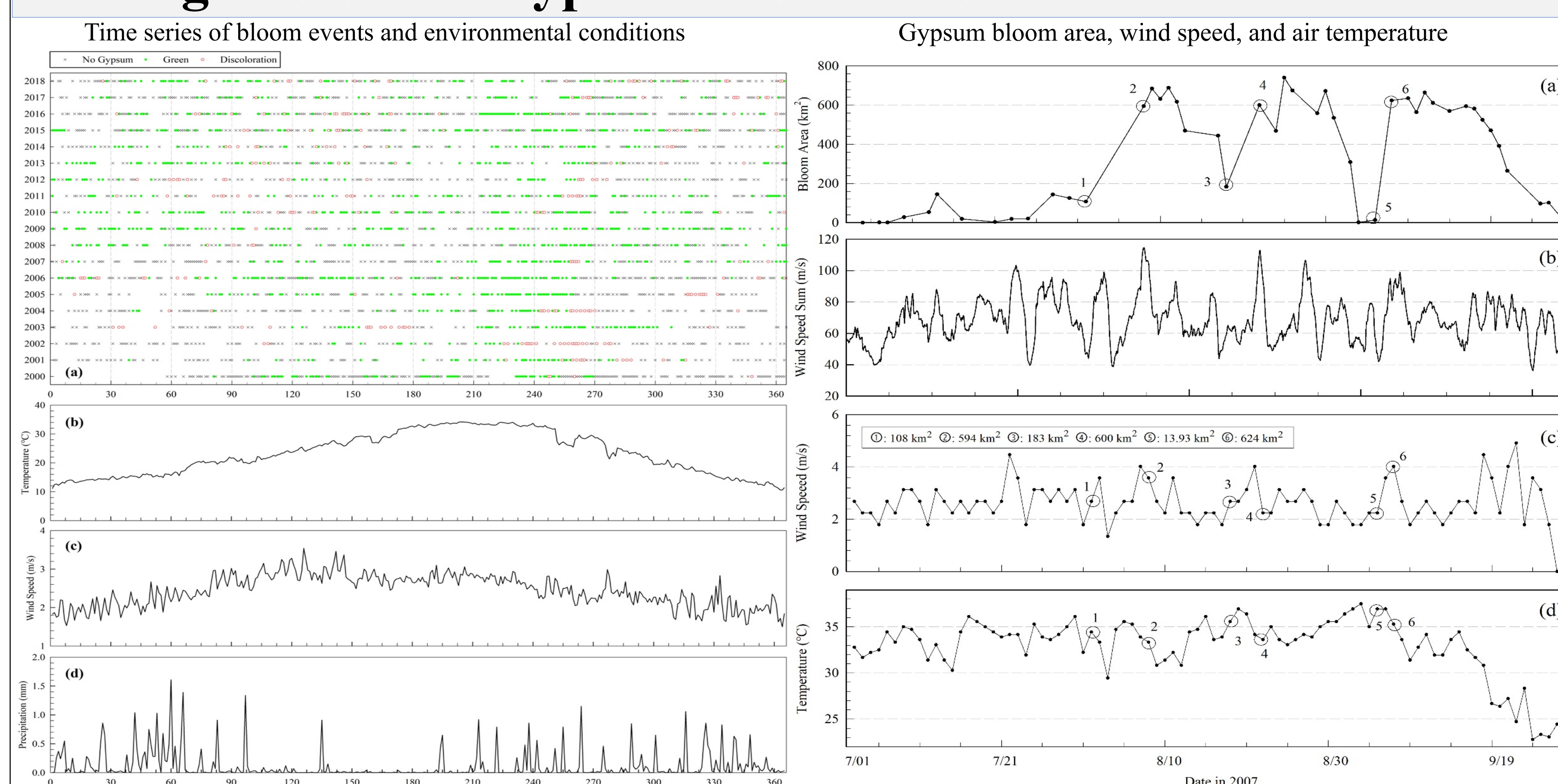

Fig. 3 Time series of bloom events and potential controlling factors. We used the proportion of the bloom area below 5%, 5%-50%, and over 50% to distinguish no Gypsum, Green, and Discoloration, respectively.

The figure shows that cumulative wind speed and temperature were important factors affecting the occurrence of the gypsum bloom events.

Summary

1) The GI can enhance the wide application of satellite remote sensing in water quality monitoring, providing a valuable reference for other inland lake water management and support for water quality management.
2) Bloom events in Salton Sea showed clear spatiotemporal patterns during 2000-2018, with highest frequency in August and September across the year and along southeastern shore, followed by southern and northern central regions spatially, but longer bloom duration was found along the southeastern shore of the lake.
3) Wind speed and temperature were important factors affecting the occurrence of the gypsum bloom events.

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