SkySearch: Satellite Video Search at Scale

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https://github.com/geon0325/skysearch

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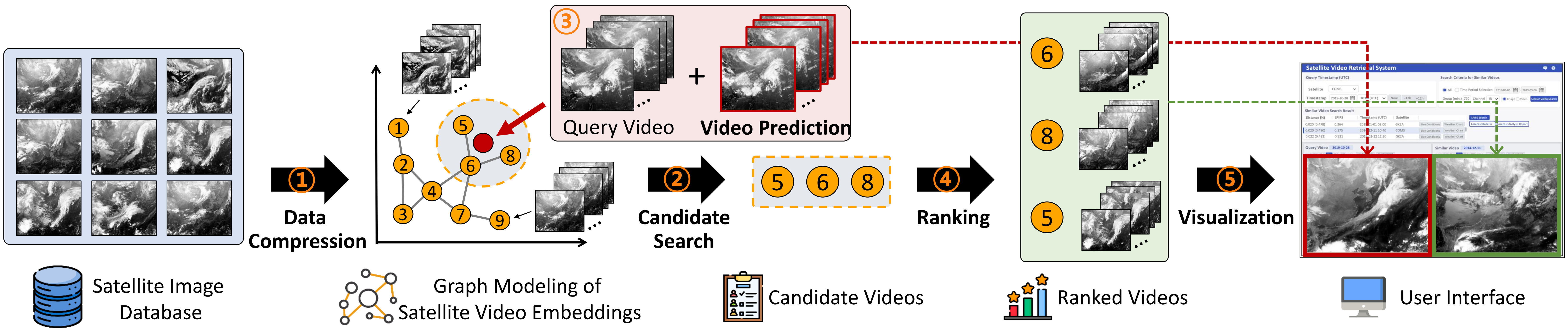


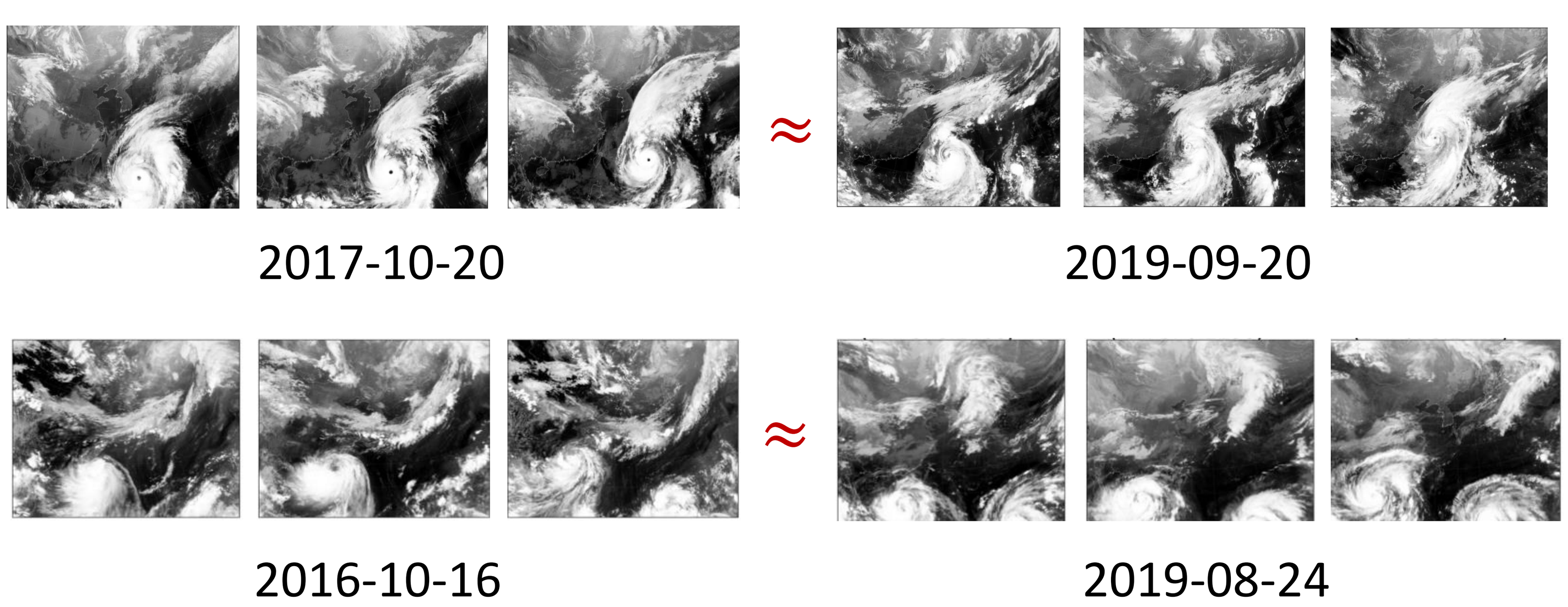
Summary

- **Summary** We develop a **large-scale satellite video retrieval system** deployed at the **Korea Meteorological Administration** (**KMA**).
- **Goal** Given a query video, **efficiently** and **accurately** search for similar satellite videos from a **massive** database.
- **Challenges** Satellite video retrieval has unique challenges:
  - **No ground-truth** for defining similarity
  - **Massive volume and resolution** of video data
- **Method** We develop **SkySearch**, an effective satellite video retrieval system deployed at **KMA** that is:
  - **Efficient:** Processes queries from a large-scale DB within seconds;
  - **Accurate:** Retrieves videos that closely align with the query video;
  - **Label-Free:** Requires no labeled data for training.

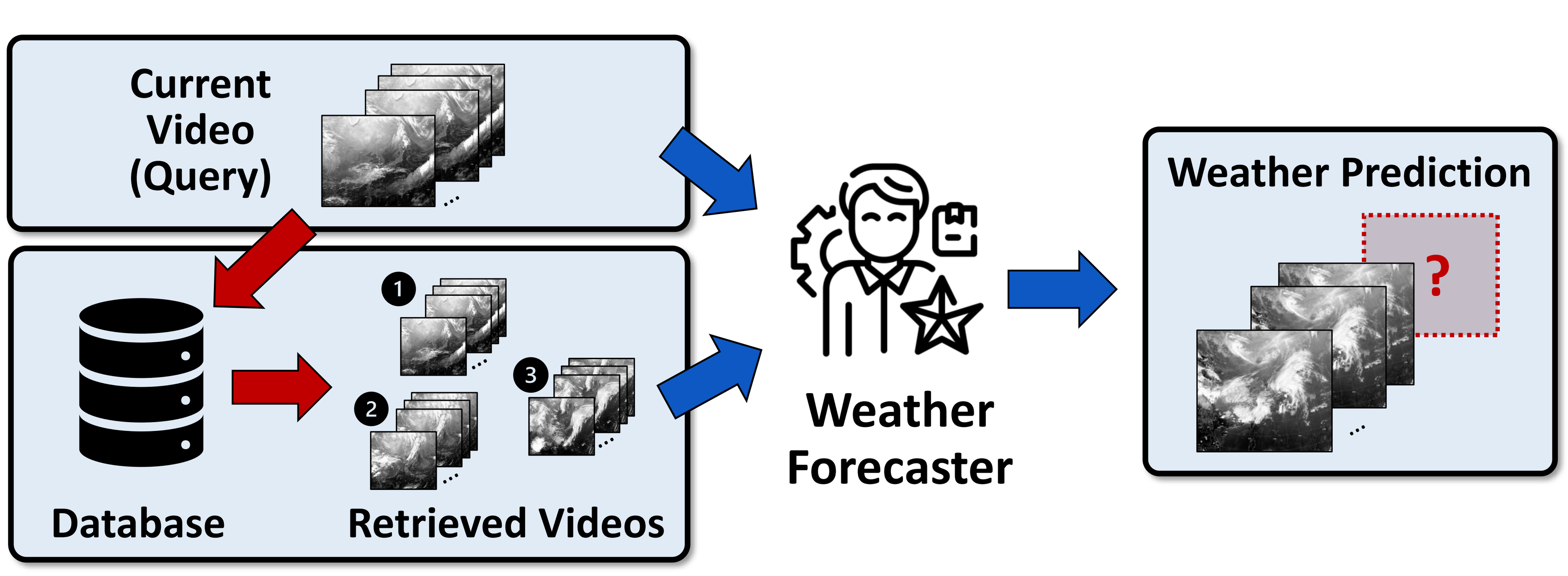
Satellite Video Search

- Weather patterns tend to **repeat** over time.

→ Analyzing h**istorical data is essential.**



- Weather forecasters at KMA **refer to past satellite videos** to better understand and interpret current weather conditions.



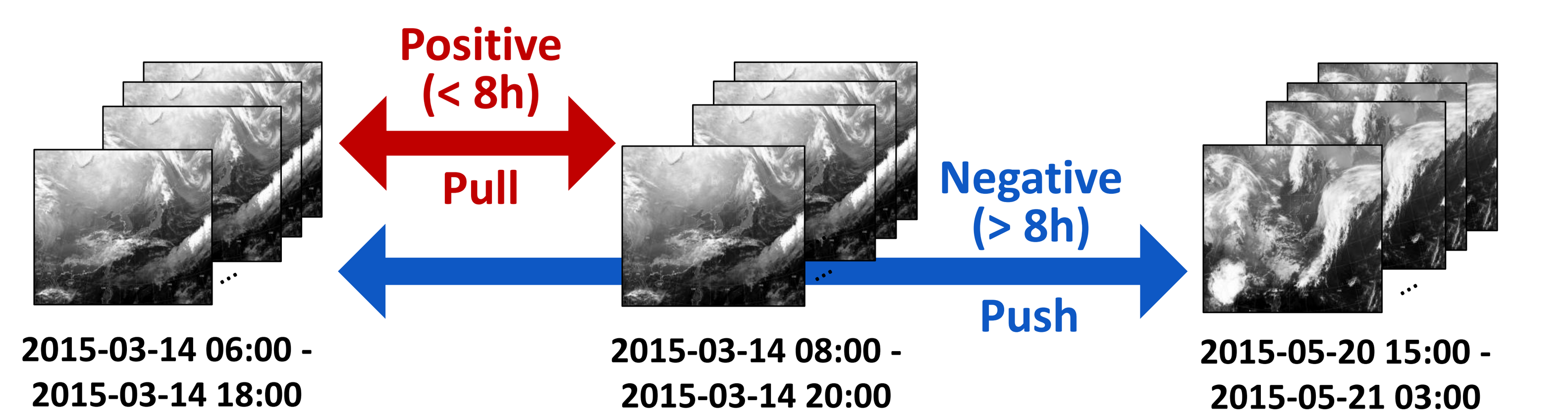
- **Satellite Video Search** supports weather forecasters in making more **accurate** and **reliable** weather predictions.
  - **Inputs:** (1) A **large-scale** database of past satellite videos **without similarity labels**;
    (2) A **query video** representing the current weather
  - **Output:** A ranked list of retrieved similar past videos
  - **Desirable properties:** The search should be **fast** and **accurate**.

Fast
Retrieve results in seconds to support real-time forecasting.

Accurate
Retrieve videos that match the query video both visually and numerically.

SkySearch

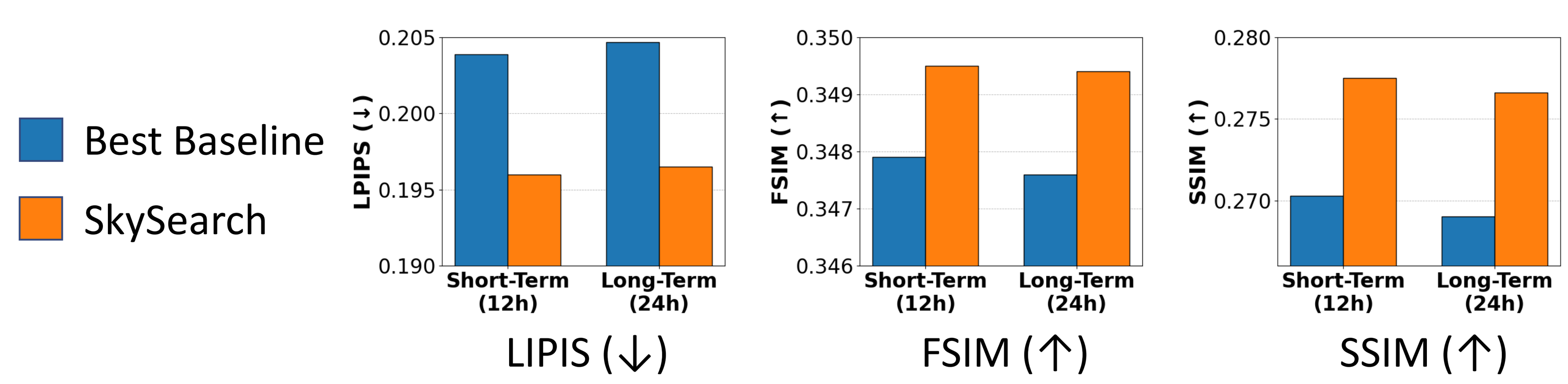
- We develop **SkySearch**, an **unsupervised real-time satellite video search system** deployed at **KMA** to support weather forecasters.
  - **Step 1. Video Compression** **Compress** satellite videos into compact latent embeddings via **self-supervised learning**.
    Weather evolves *gradually* over time; **temporal proximity ≈ semantic similarity**



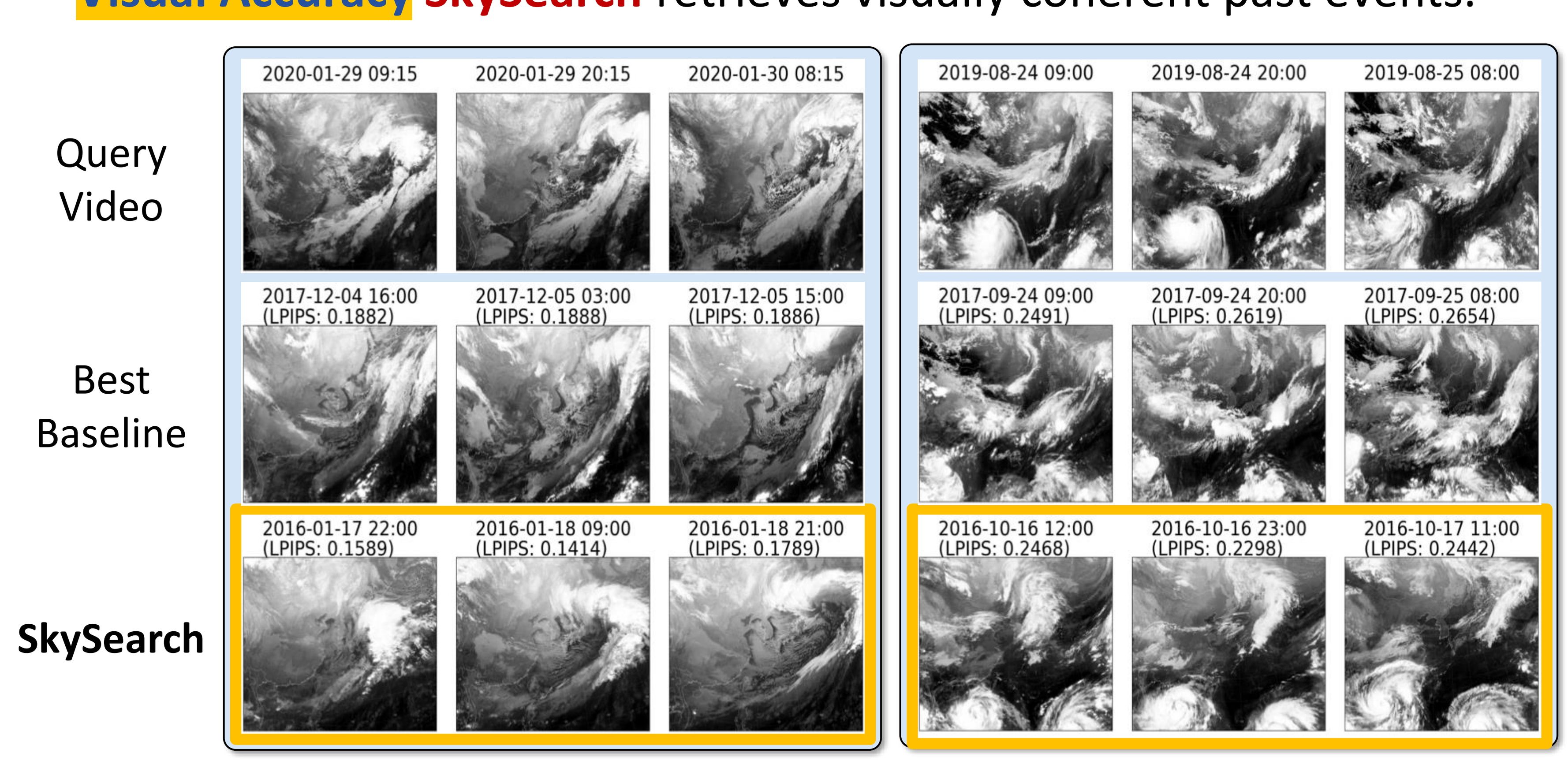
  - **Step 2. Graph-Based Search** Construct a **K-NN graph** by connecting videos that are both temporally close and have similar embeddings.
  - **Step 3. Video Prediction** **Augment** the query video with **predicted future frames** to enhance long-term video search.
  - **Step 4. Ranking** **Rank** the retrieved candidates by embedding distance or perceptual similarity, or prioritizing relevant results.
  - **Step 5. Visualization** **Display** the ranked results through a UI.

Experimental Results

- **Deployment** **SkySearch** is deployed at **KMA**.
  - **Satellite sources:** COMS & GK2A / **Channels:** IR, SWIR, WV / 12 years
- **Numerical Accuracy** **SkySearch** outperforms baselines on all metrics.



- **Visual Accuracy** **SkySearch** retrieves visually coherent past events.



- **Speed** **SkySearch** searches candidate videos rapidly and accurately.