

Introduction of Space Weather and Application of Deep Learning

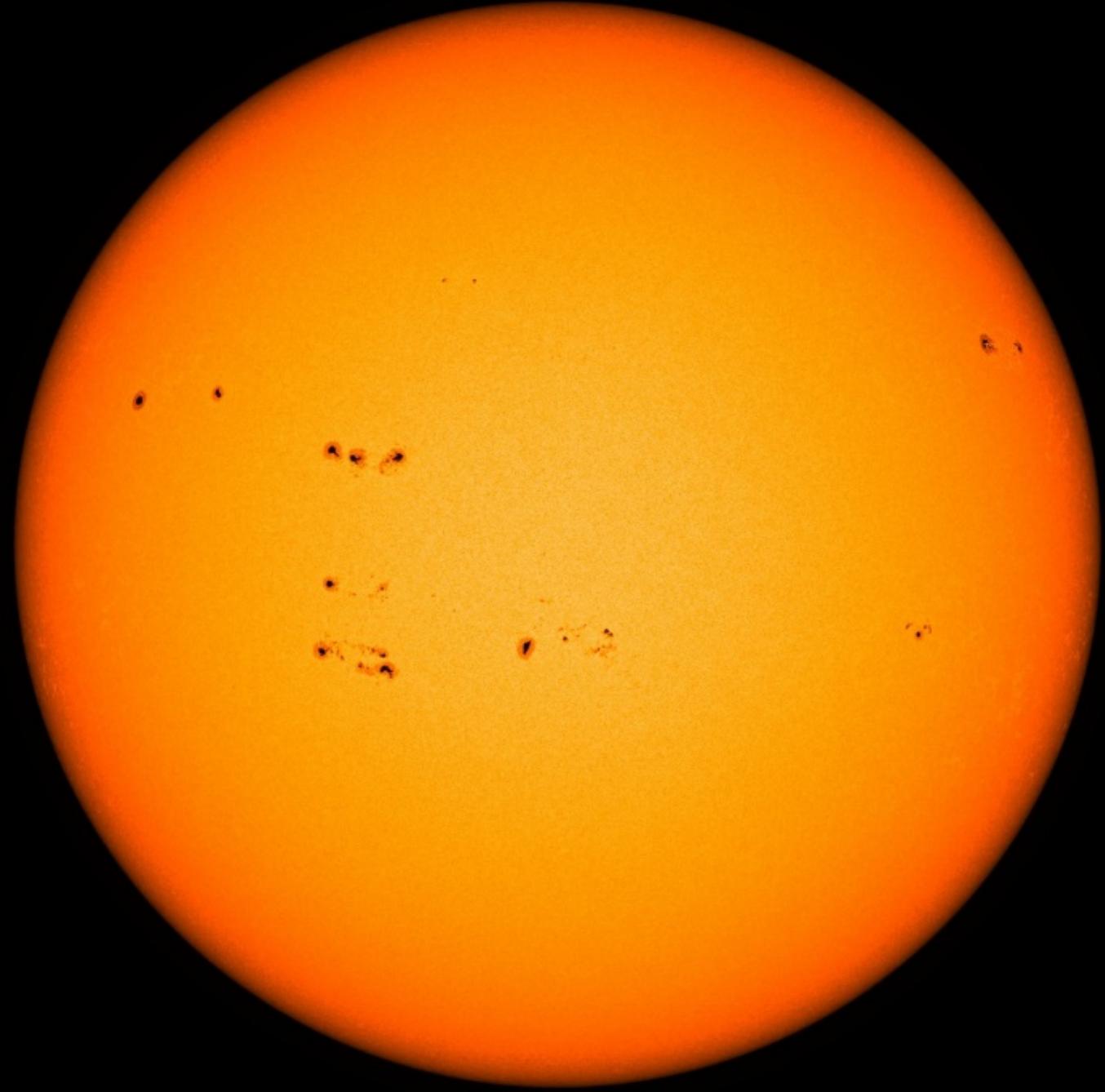
Eunsu Park
[espark@khu.ac.kr]

Sun & Space Weather Lab.
School of Space Research, Kyung Hee University

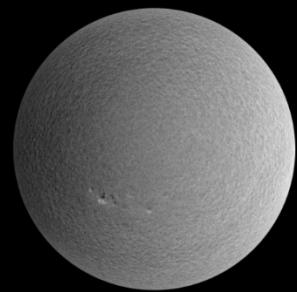
Q : Space Weather?



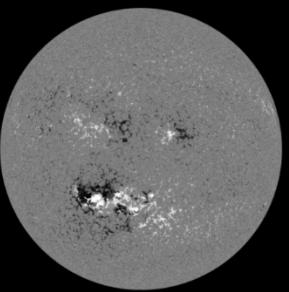
SDO/HMI Continuum
2014.04.17 15:30:00



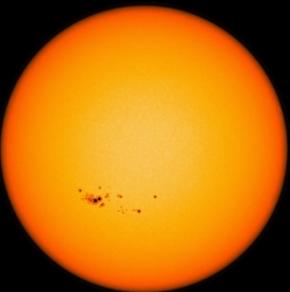
Solar Dynamics Observatory Wavelengths



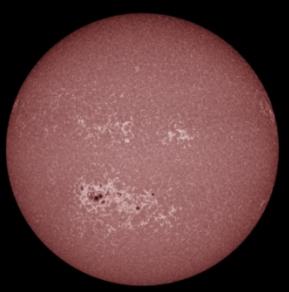
HMI Dopplergram
Surface movement
Photosphere



HMI Magnetogram
Magnetic field polarity
Photosphere



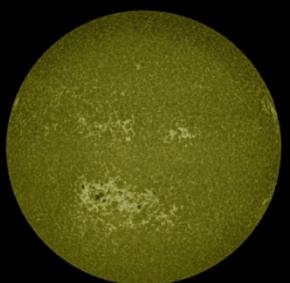
HMI Continuum
Matches visible light
Photosphere



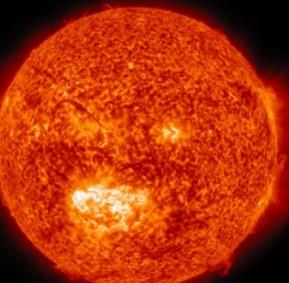
AIA 1700 Å
4500 Kelvin
Photosphere



AIA 4500 Å
6000 Kelvin
Photosphere



AIA 1600 Å
10,000 Kelvin
Upper photosphere/
Transition region



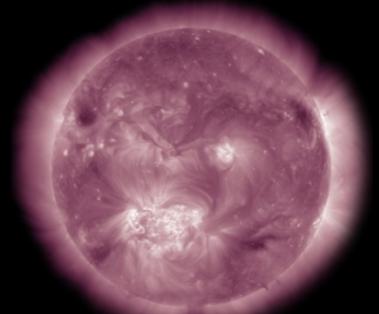
AIA 304 Å
50,000 Kelvin
Transition region/
Chromosphere



AIA 171 Å
600,000 Kelvin
Upper transition
Region/quiet corona



AIA 193 Å
1 million Kelvin
Corona/flare plasma



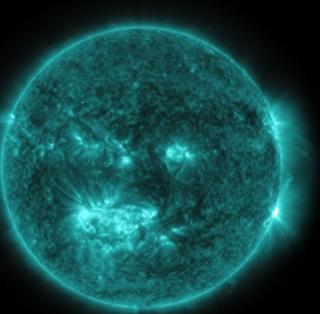
AIA 211 Å
2 million Kelvin
Active regions



AIA 335 Å
2.5 million Kelvin
Active regions



AIA 094 Å
6 million Kelvin
Flaring regions



AIA 131 Å
10 million Kelvin
Flaring regions

Solar Flare
2003/10/28~30
SOHO/EIT



Coronal Mass Ejections

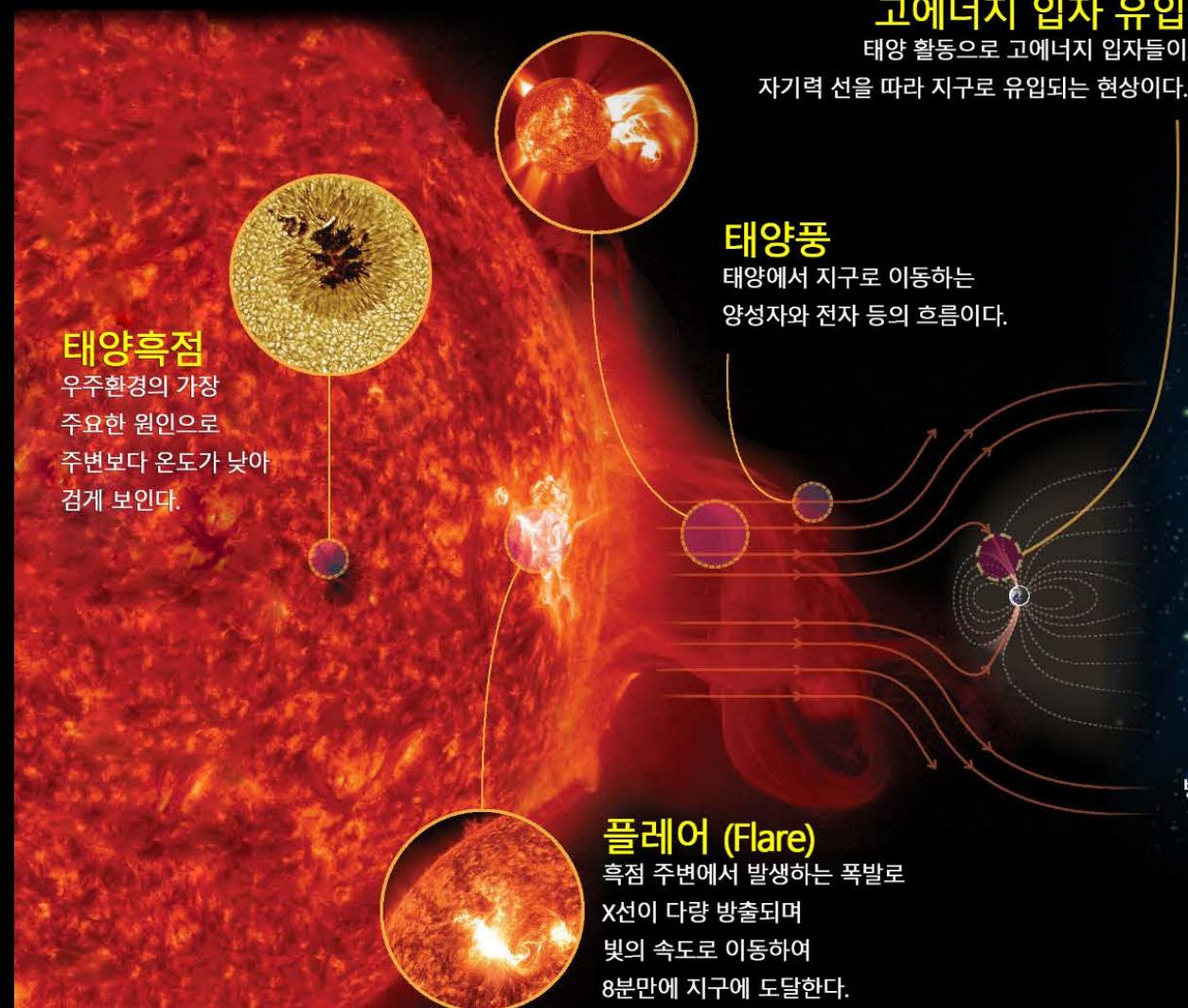
2003/10/25~30

SOHO/LASCO



코로나물질방출 (CME)

태양 표면에서 발생하는 흑점 폭발과는 다르며
태양의 외부 대기층 밖으로 폭발하며 발생하는 플라즈마 덩어리가
우주공간으로 방출되는 현상으로 지구 자기장에 영향을 미친다.



태양흑점

우주환경의 가장
주요한 원인으로
주변보다 온도가 낮아
검게 보인다.

플레어 (Flare)

흑점 주변에서 발생하는 폭발로
X선이 다량 방출되며
빛의 속도로 이동하여
8분만에 지구에 도달한다.

고에너지 입자 유입

태양 활동으로 고에너지 입자들이
자기력 선을 따라 지구로 유입되는 현상이다.

태양풍

태양에서 지구로 이동하는
양성자와 전자 등의 흐름이다.

위성분야

위성체 내부 깊숙히 전자들이 쌓이게 되면
반도체 등 민감한 부품에 손상을 입히고
태양 전지판의 성능을 저하시켜
수명이 감소 될 수 있다.



항공분야

태양 활동이 활발할 경우
극항로를 운항하는 항공기에
방사선 피폭 피해를 유발 할 수 있다.



항법분야

GPS 신호가 굴절되거나 위상에 변화가 생겨
전파를 통해 전달되는 정보의 손실이 발생 할 수 있다.



통신분야

전파 중계의 교란으로
군 및 위성통신에서
전파 송수신 장애가 발생 할 수 있다.



전력분야

지자기 폭풍 발생 시 유도 전류가 생겨
전력 배선망과 변압기에 이상을 가져오며
이로 인해 대규모 정전이 발생 할 수 있다.

1997년 (프랑스 / ARIANE 로켓)

로켓 발사 통제 시스템의 전자장비 장애발생

Mt. Bohyun
30 October 2003
2 22 15

630.0 nm Aurora

N

2001년 (미국 / Athena 로켓)

태양 활동으로 인하여 발사 연기

2003년 (한국 / 무궁화위성)

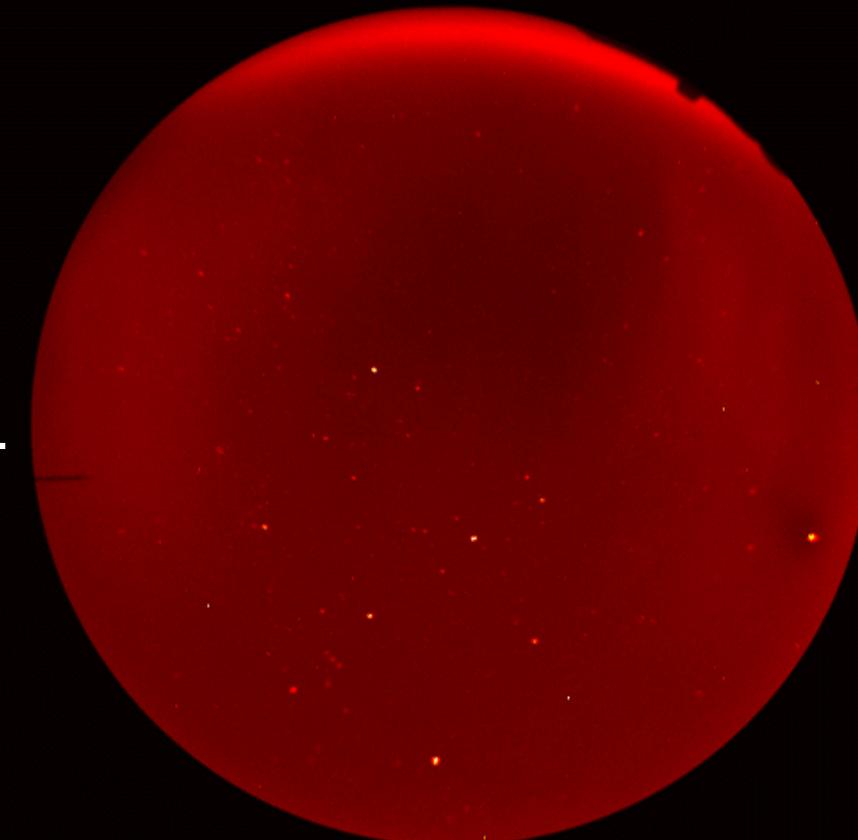
노이즈 증폭, 태양전지판 성능 감소, 위치 에러 증폭

1989년 (캐나다 퀘벡)

변압기 손상으로 인한 9시간 정전 사태

1998년 (미국, 갤럭시4위성)

통신위성 작동 불능으로 인한 미국 전역 통신 마비

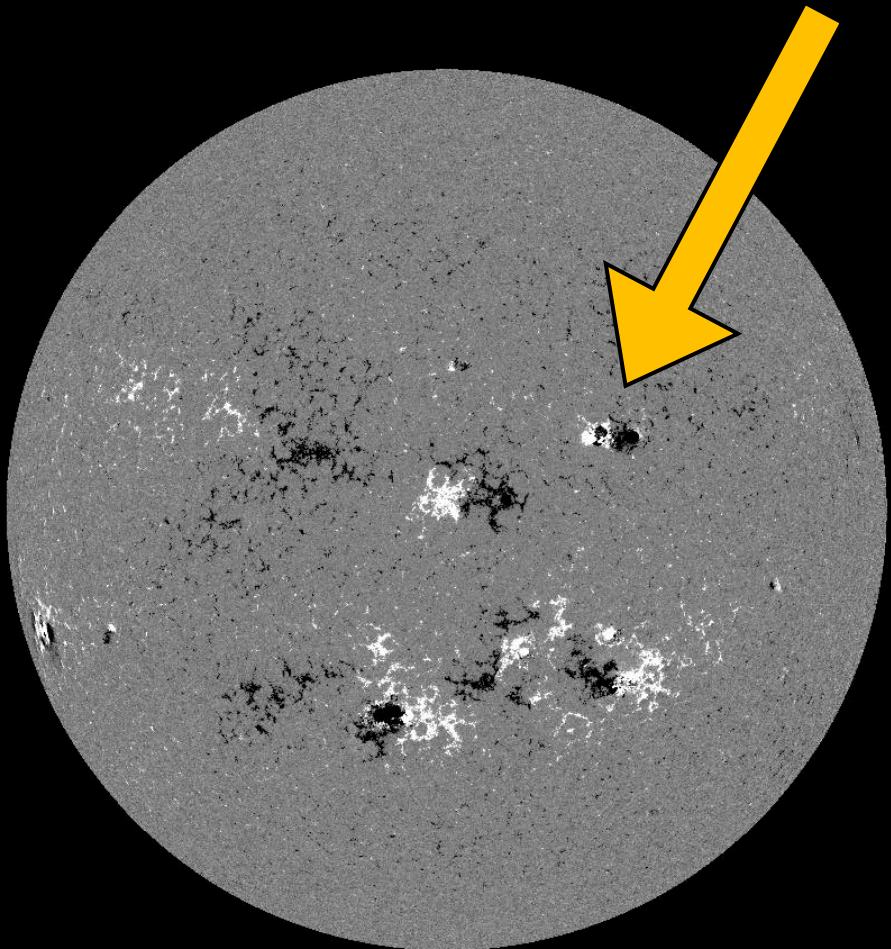


Space Weather Lab. in KHU

1. 태양 활동에 대한 물리적 이해
2. 태양 활동으로부터 발생하는 위험을 예측 및 예보하기 위한 모델 개발 및 배포

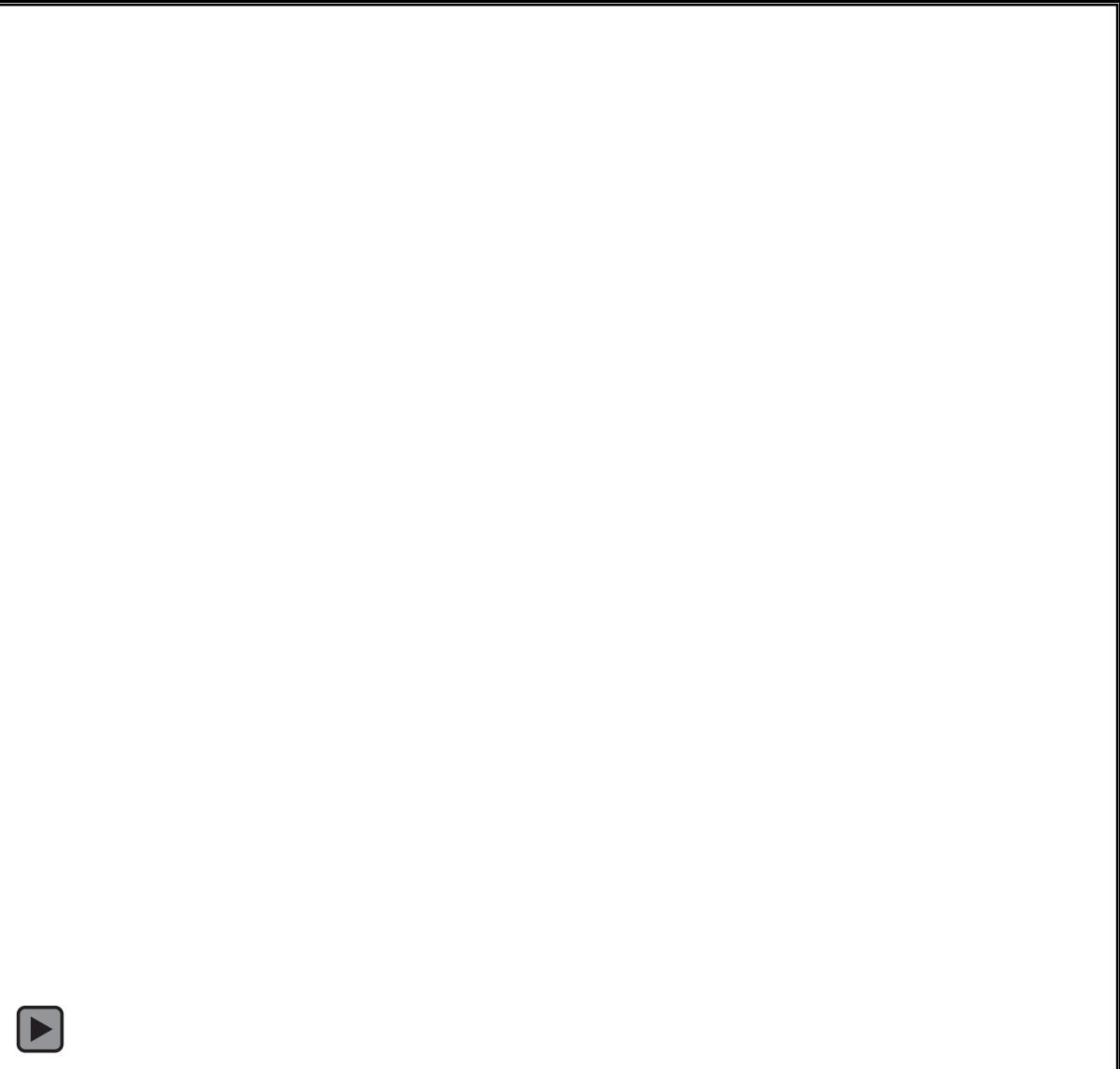
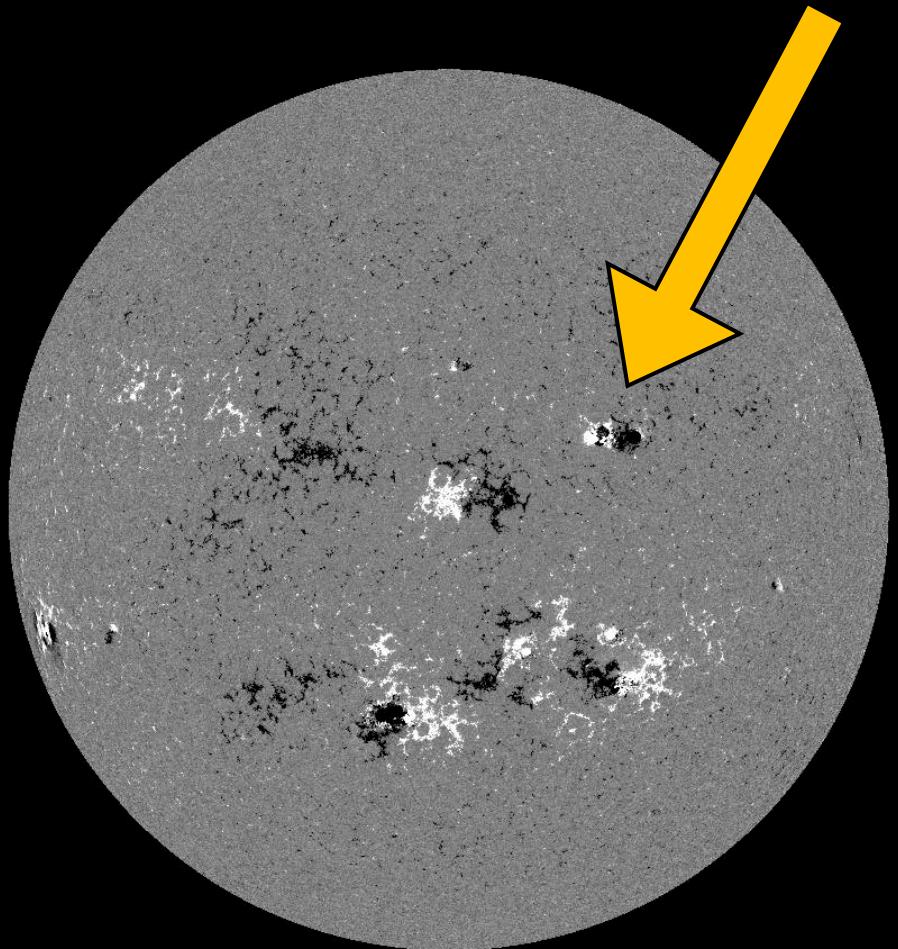
태양 자기장 영상을 이용한 태양 흑점 폭발 예보 모델 개발

Active Region



Magnetogram
SOHO/MDI & SDO/HMI

Active Region



24시간 태양 폭발 예보 모델 개발

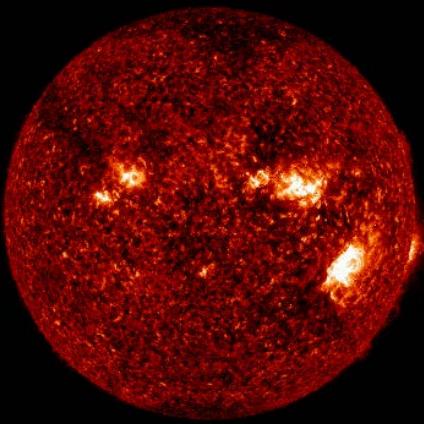
(Park et al. *Astrophysical Journal, in progress*)

	CNN Park et al. (2018)	ML Colak and Qahwaji (2009)	Statistics Bloomfield et al. (2012)	CNN Huang et al. (2018)
ACC	0.82			0.76
POD	0.85	0.81	0.75	0.73
CSI	0.75			0.31
FAR	0.17	0.30	0.65	0.65
HSS	0.63	0.51	0.32	0.34
TSS	0.63		0.46	0.49

Extreme Ultraviolet (EUV, 극자외선) 영상을 이용한 태양 자기장 영상 생성

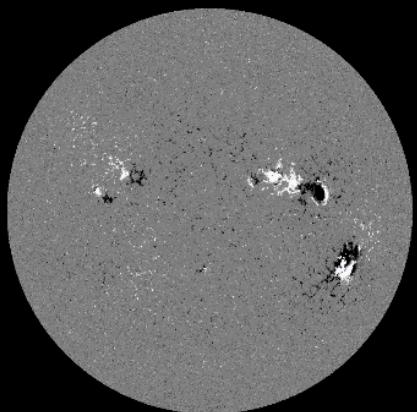
Input

Training



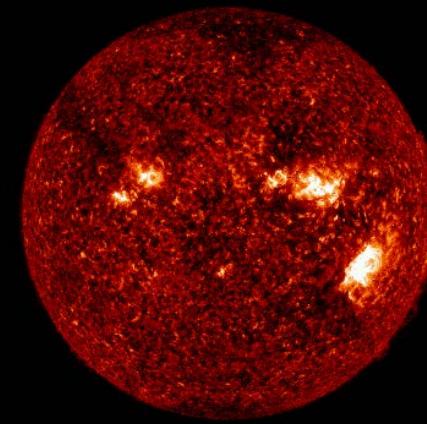
SDO/AIA
EUV Images
(2011~2017
Except
Sep & Oct)

Output



SDO/HMI
Magnetograms
(2011~2017
Except
Sep & Oct)

Test



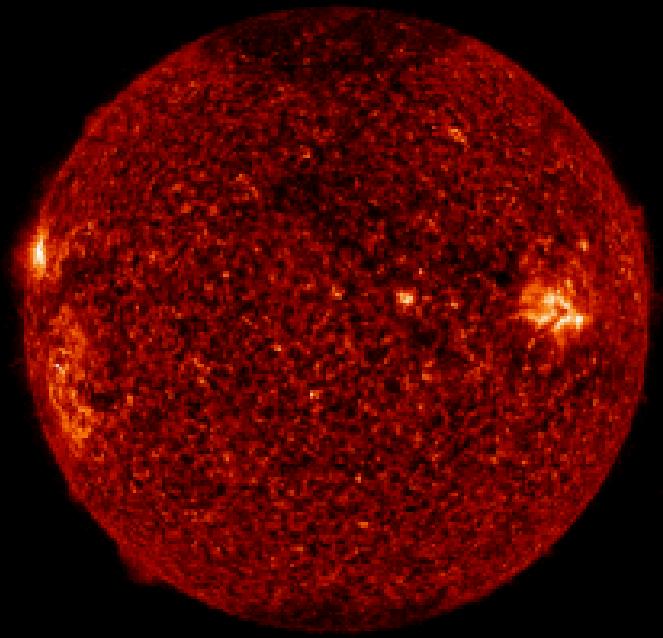
SDO/AIA
EUV Images
(Sep & Oct)



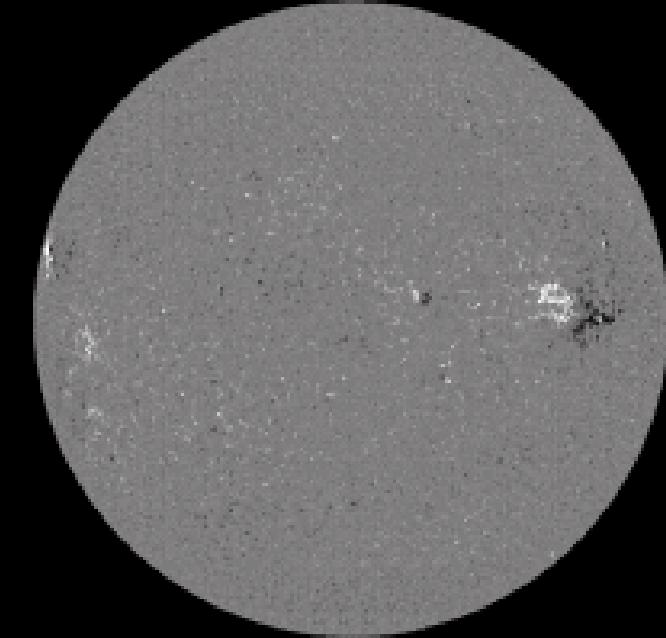
AI-generated
Magnetograms
(Sep & Oct)

20170830 00:00 [UT]

SDO/AIA 304

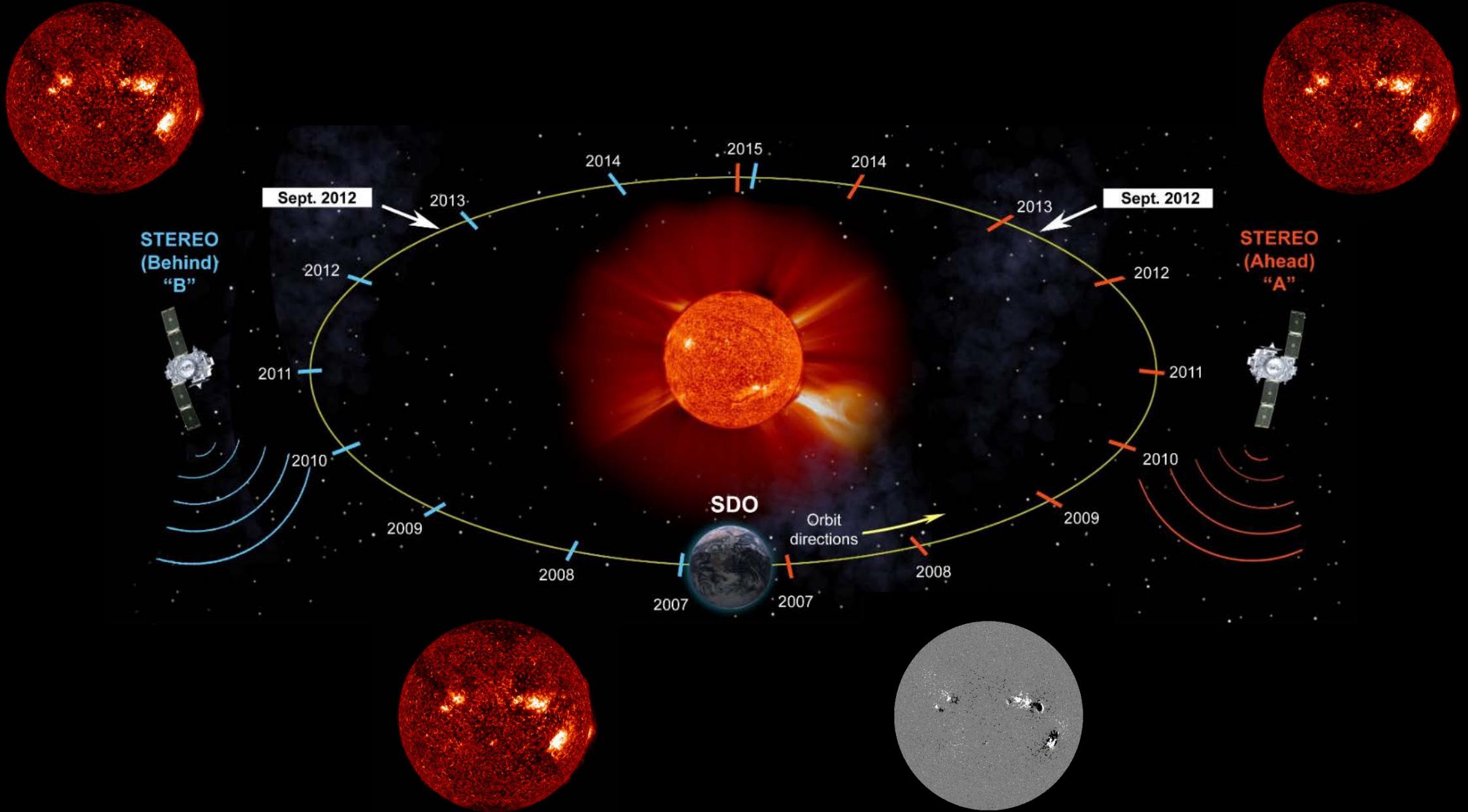


AI_generated

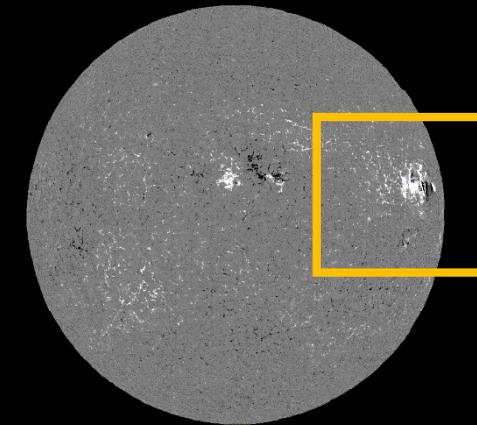
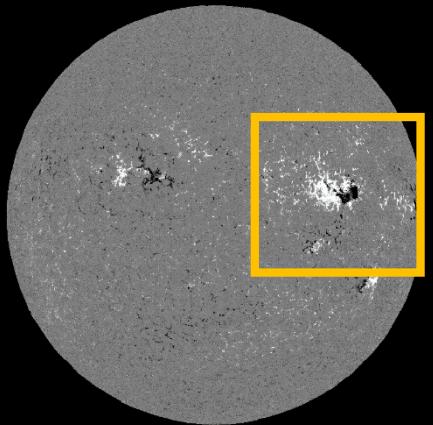
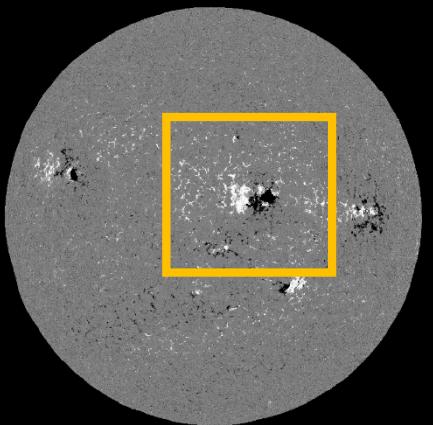
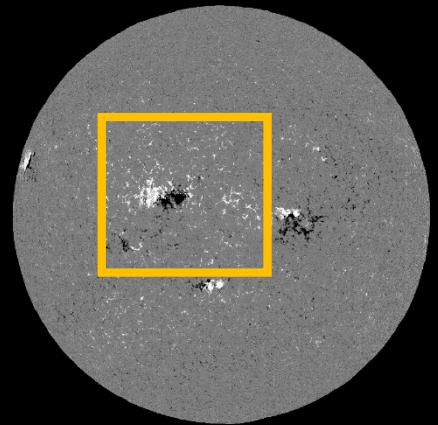


SDO/HMI

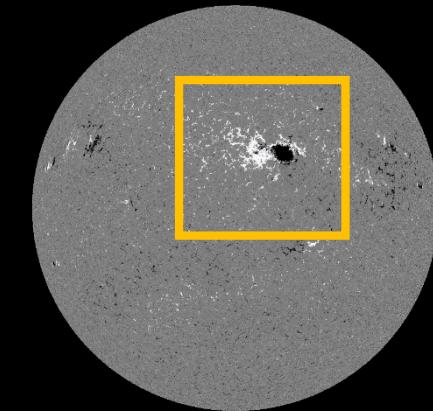
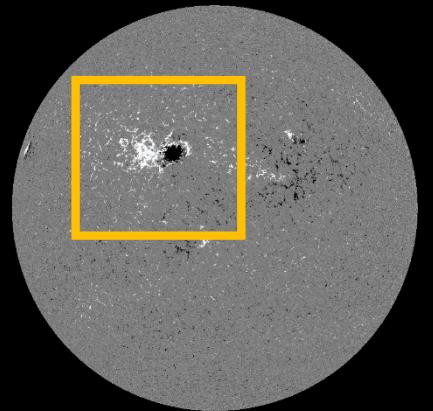
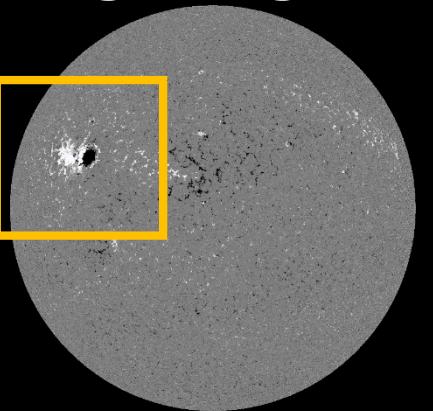
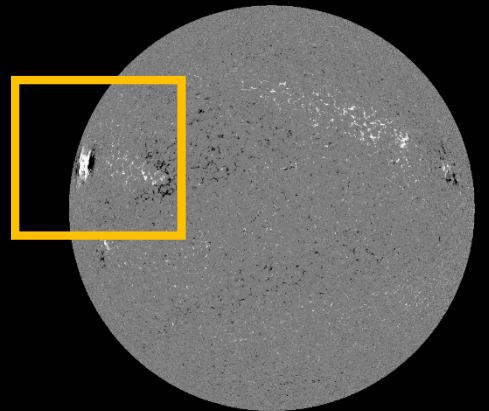




태양 후면 자기장 영상 생성 모델 개발 (Kim et al. Nature Astronomy, in progress)



Constructed back-side magnetograms

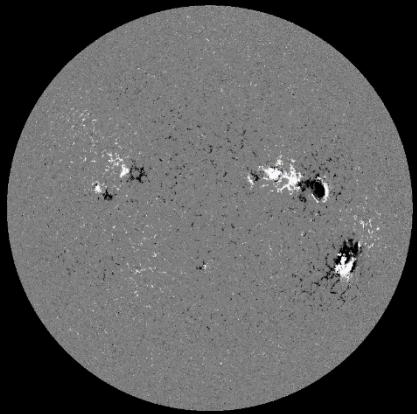


Real HMI front-side magnetograms

태양 자기장 영상을 이용한
극자외선 영상 생성

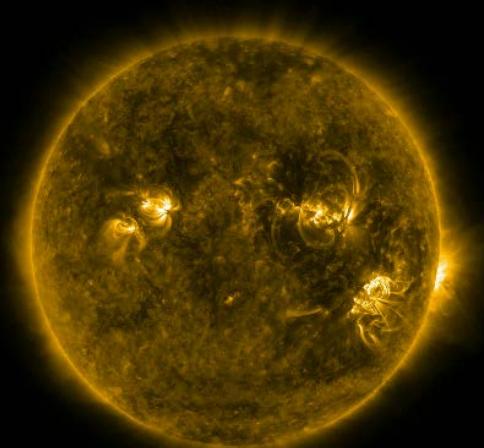
Input

Training



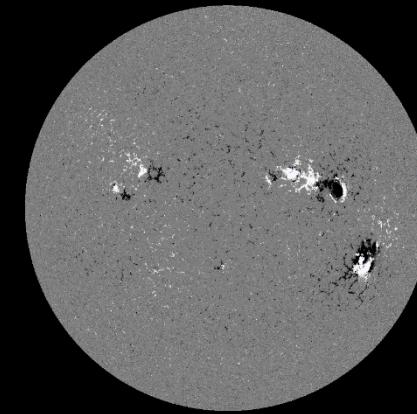
**SDO/HMI
Magnetograms
(2011~2017
Except
Sep & Oct)**

Output



**SDO/AIA
9 Wavelengths
EUV Images
(2011~2017
Except
Sep & Oct)**

Test

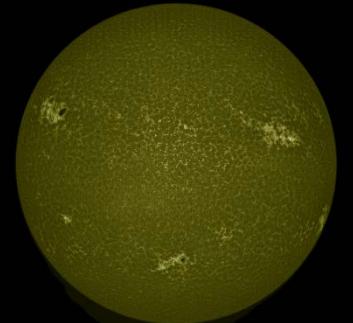
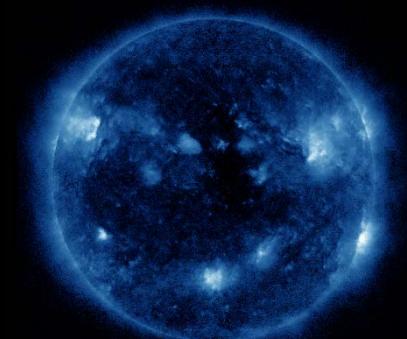
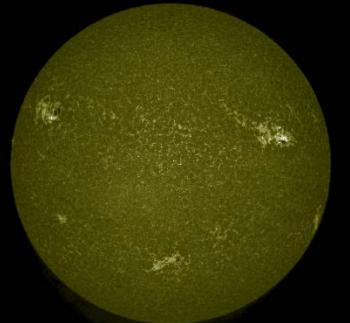
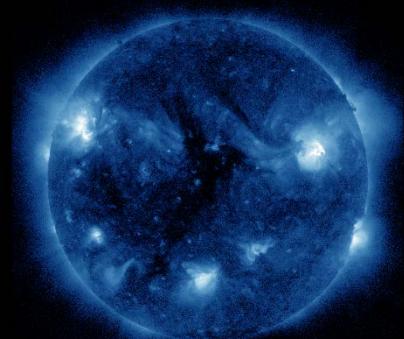
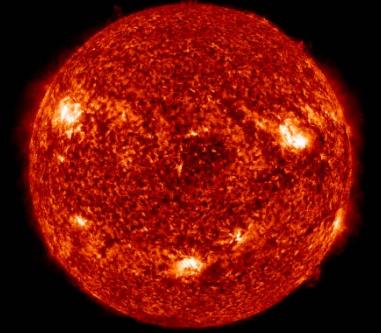
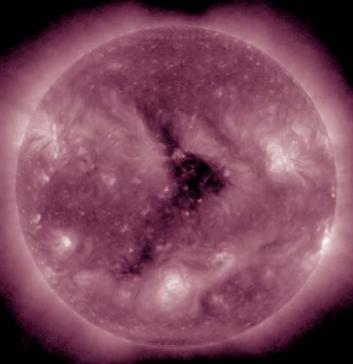
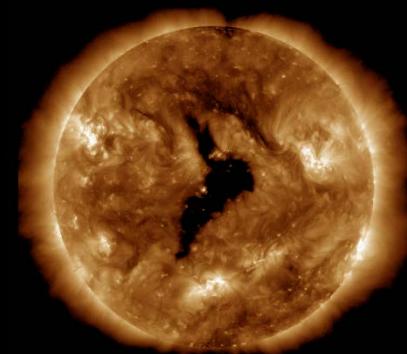
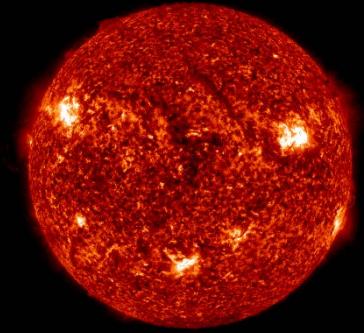
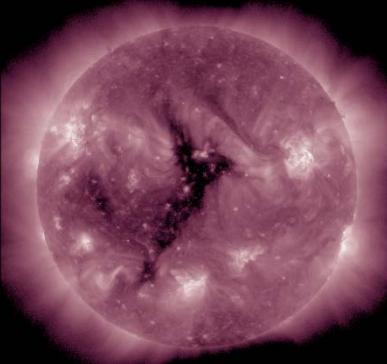
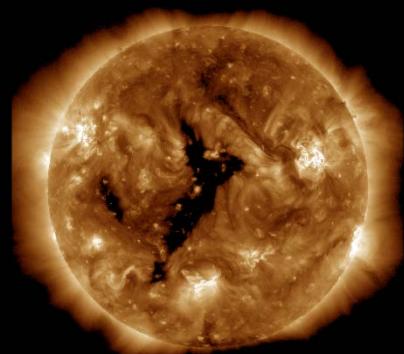
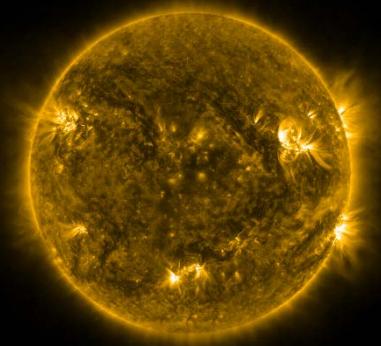
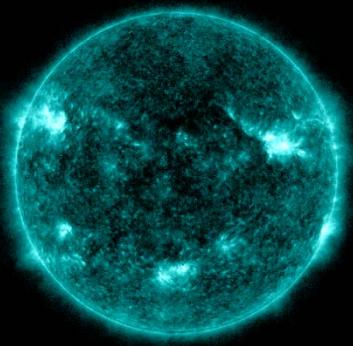
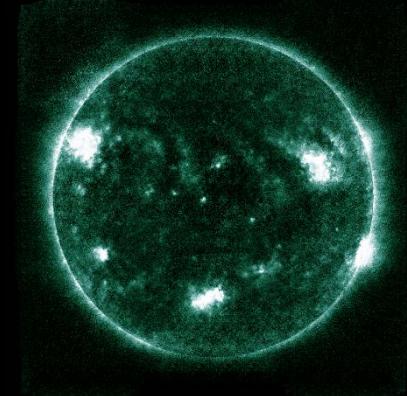
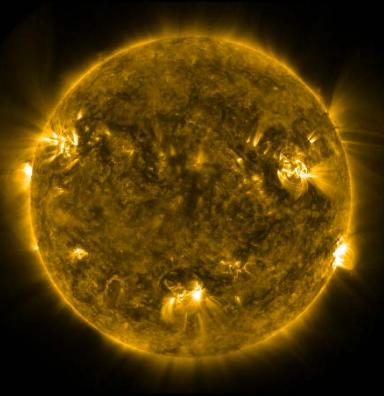
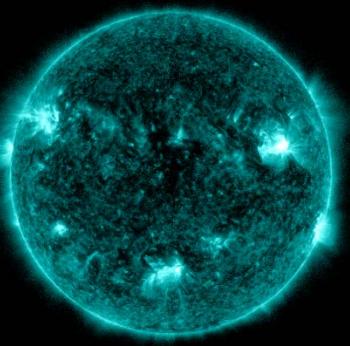
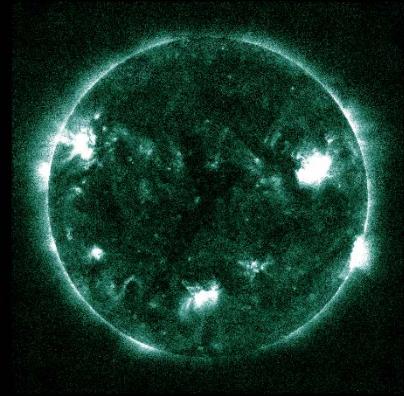


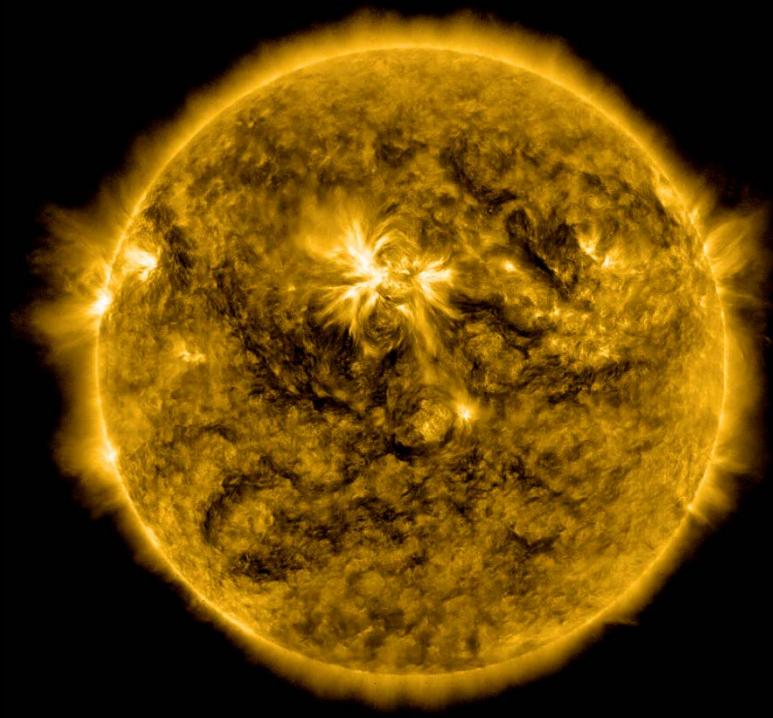
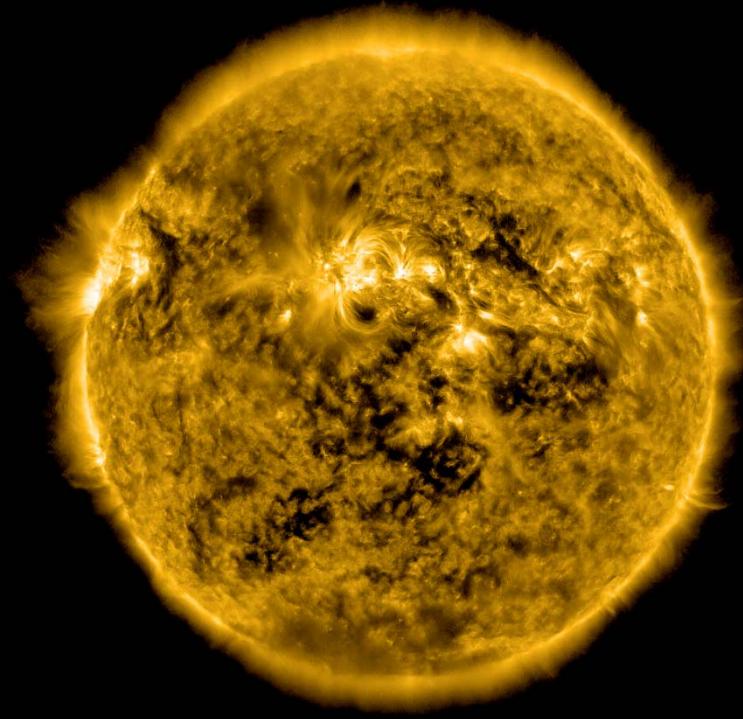
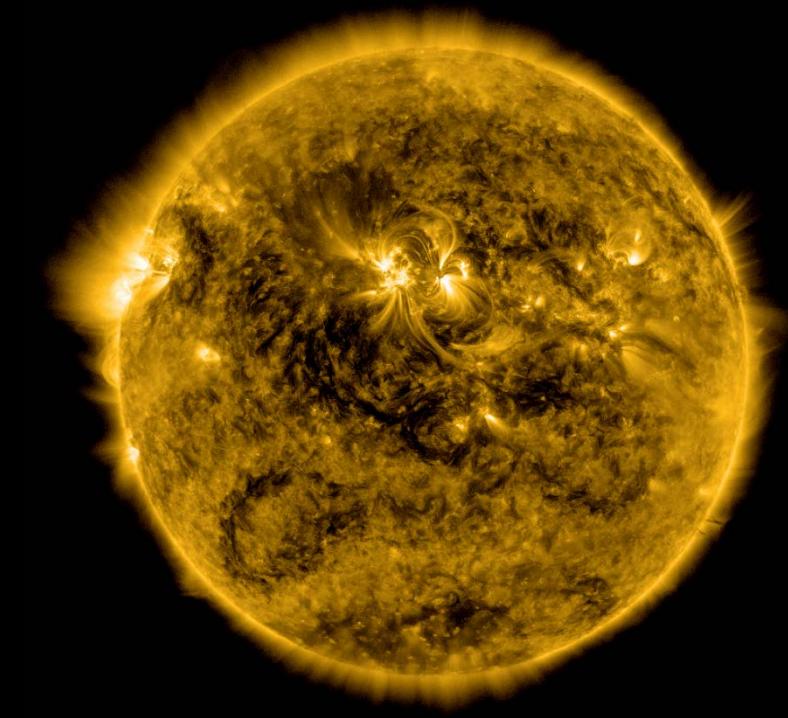
**SDO/HMI
Magnetograms
(Sep & Oct)**



**AI-generated
9 Wavelengths
EUV Images
(Sep & Oct)**

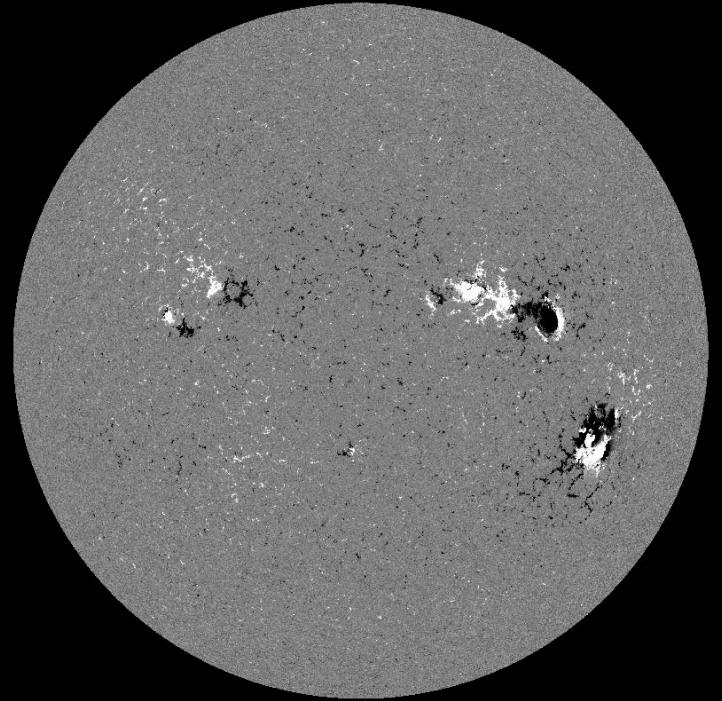
Can you distinguish which one is real or fake?



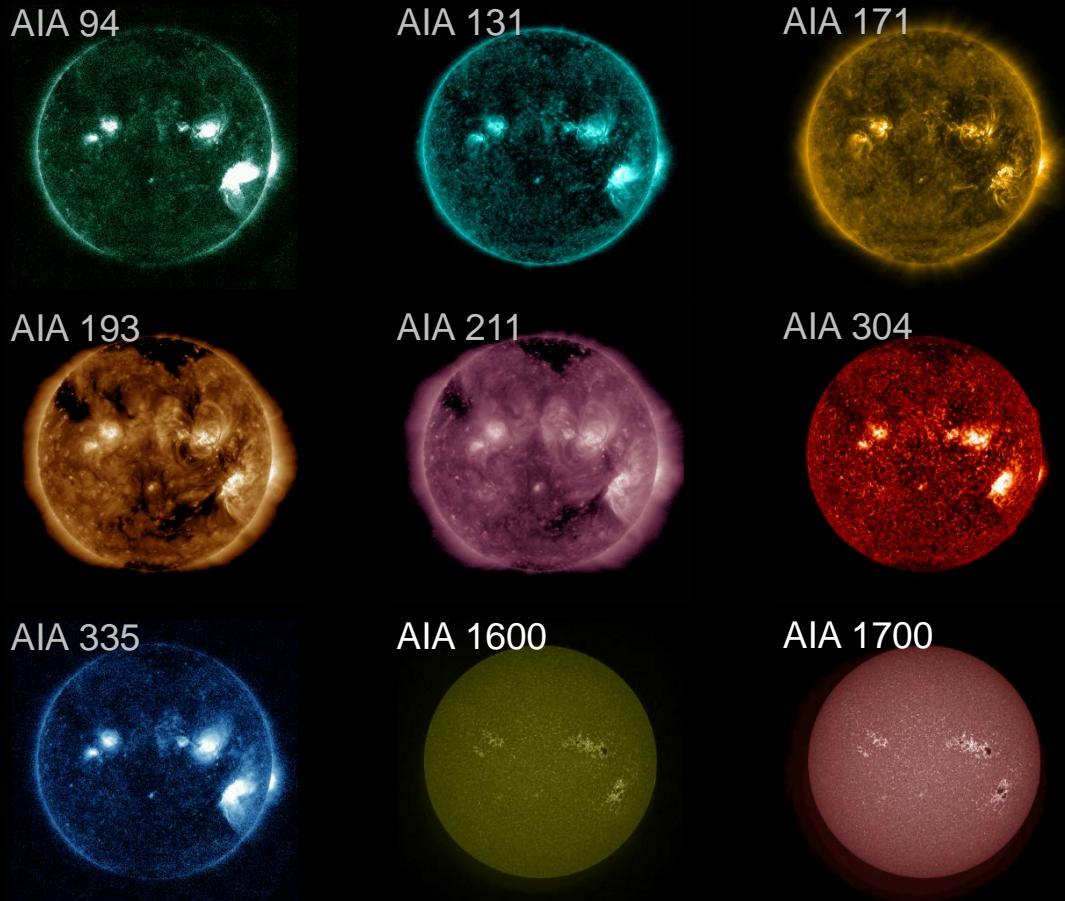
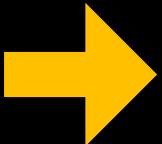


태양 극자외선 영상 생성 모델 개발

(Park et al. International Astronomical Union Meeting)



Real SDO/HMI magnetogram

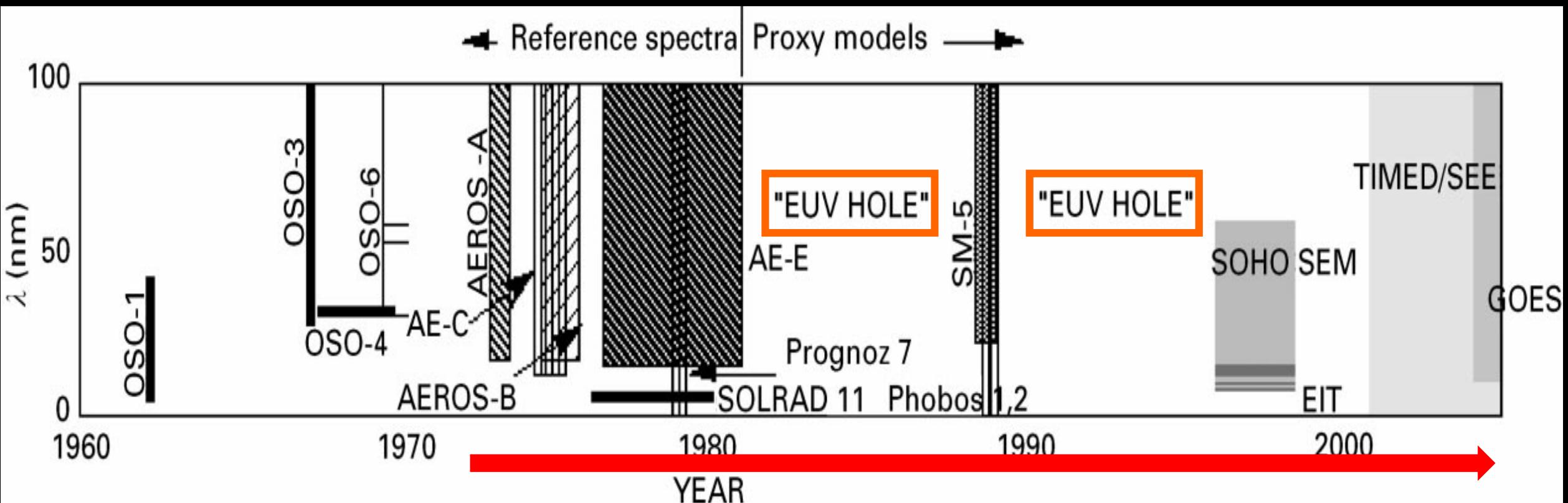


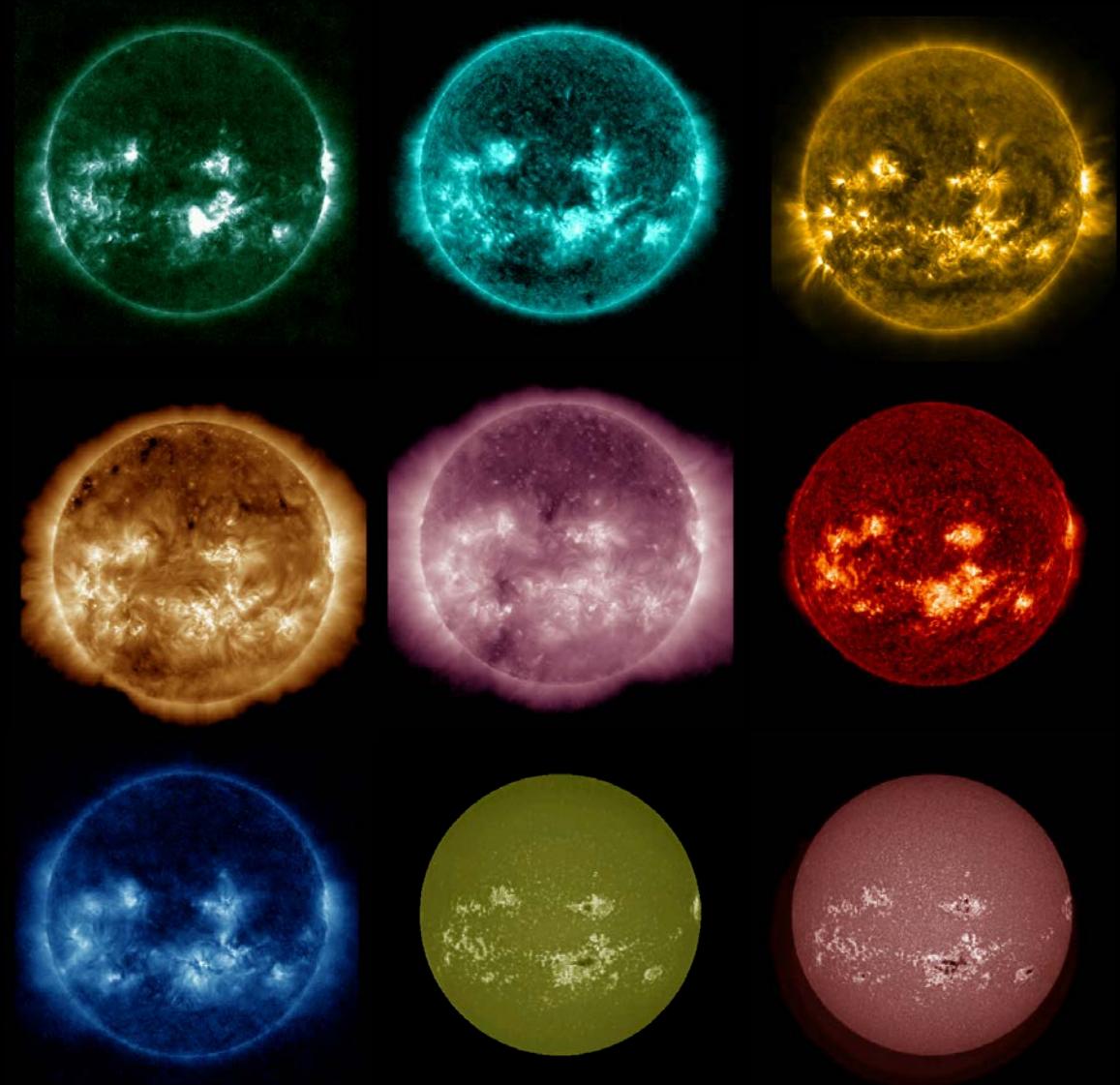
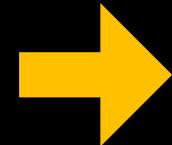
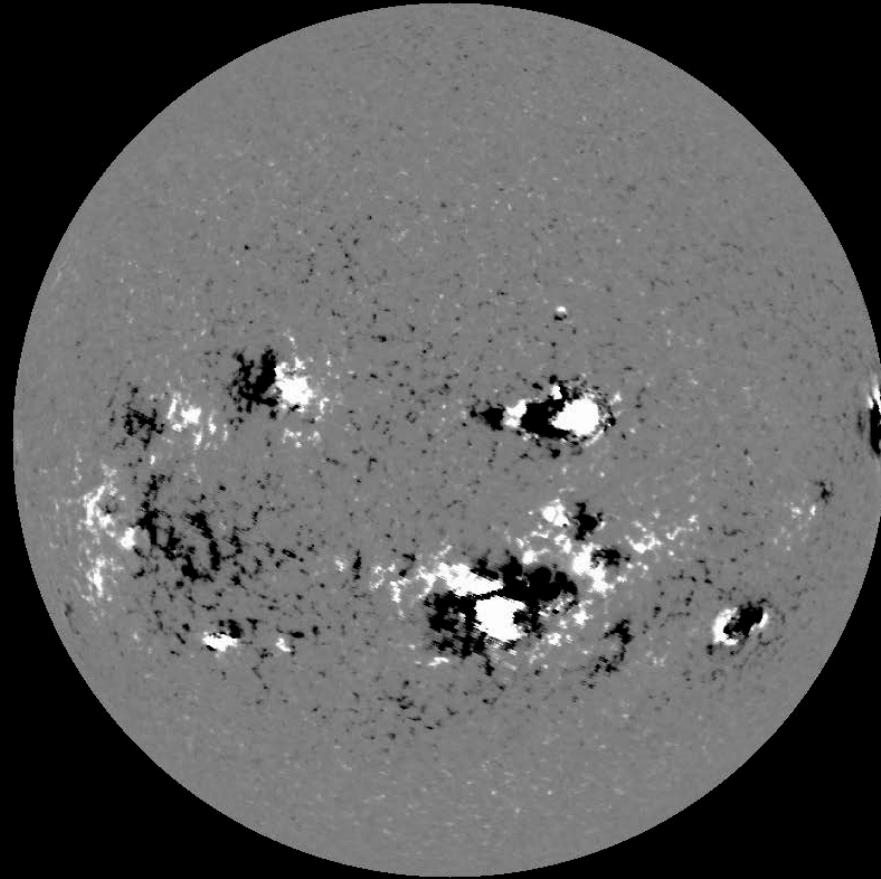
AI-generated EUV images

Input	HMI	AIA 94	HMI	AIA 131	HMI	AIA 171	HMI	AIA 193	HMI	AIA 211
Output	AIA 94	HMI	AIA 131	HMI	AIA 171	HMI	AIA 193	HMI	AIA 211	HMI
CC	0.55	0.87	0.68	0.48	0.76	0.87	0.83	0.88	0.88	0.60
Temp. (K)	6,000,000		10,000,000		600,000		1,000,000		2,000,000	
Region	Flaring Region		Flaring Region		Quiet Corona, Upper Transition Region		Corona, Hot Flare Plasma		Active Region Corona	

Input	HMI	AIA 304	HMI	AIA 335	HMI	AIA 1600	HMI	AIA 1700	HMI	AIA 4500
Output	AIA 304	HMI	AIA 335	HMI	AIA 1600	HMI	AIA 1700	HMI	AIA 4500	HMI
CC	0.66	0.82	0.72	0.84	0.68	0.77	0.76	0.91	0.99	0.60
Temp. (K)	50,000		2,500,000		10,000		4,500		6,000	
Region	Chromosphere, Transition Region		Active Region Corona		Transition Region, Upper Photosphere		Photosphere		Photosphere	

Kitt Peak magnetogram (since 1974) → EUV images





Real Kitt Peak magnetogram

AI-generated EUV images !

Space Weather...

1. 질 좋고 양 많은 데이터가 60년대 이후로
2. (거의) 모든 데이터는 오픈
3. 딥러닝은 아직...

Thank you!