Solar Activity Predictions and a Shallow Solar Dynamo

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ai-solutions

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Thanks to colleagues: Mayr, Pesnell, Scherrer, S. Sofia, Svalgaard, Wilcox, and others.

Solar Activity Prediction Methods

- METHOD: SOLAR- PRECURSOR METHOD USES SUN'S POLAR FIELD TO PREDICT FUTURE SOLAR ACTIVITY
- OTHER
  - "CLIMATOLOGY" (AVERAGE SOLAR ACTIVITY)
  - RECENT CLIMATOLOGY (RECENT AVERAGE)
  - GEO-MAGNETIC PRECURSOR
  - (GEO FIELD VARS.: PROXY OF SOLAR FIELD)
  - DYNAMO MODELS (MEAN FIELD, MODEL DEPENDENT)
  - NEURAL NETWORK (NUMERICAL)
  - SPECTRAL (NUMERICAL, UNPHYSICAL)

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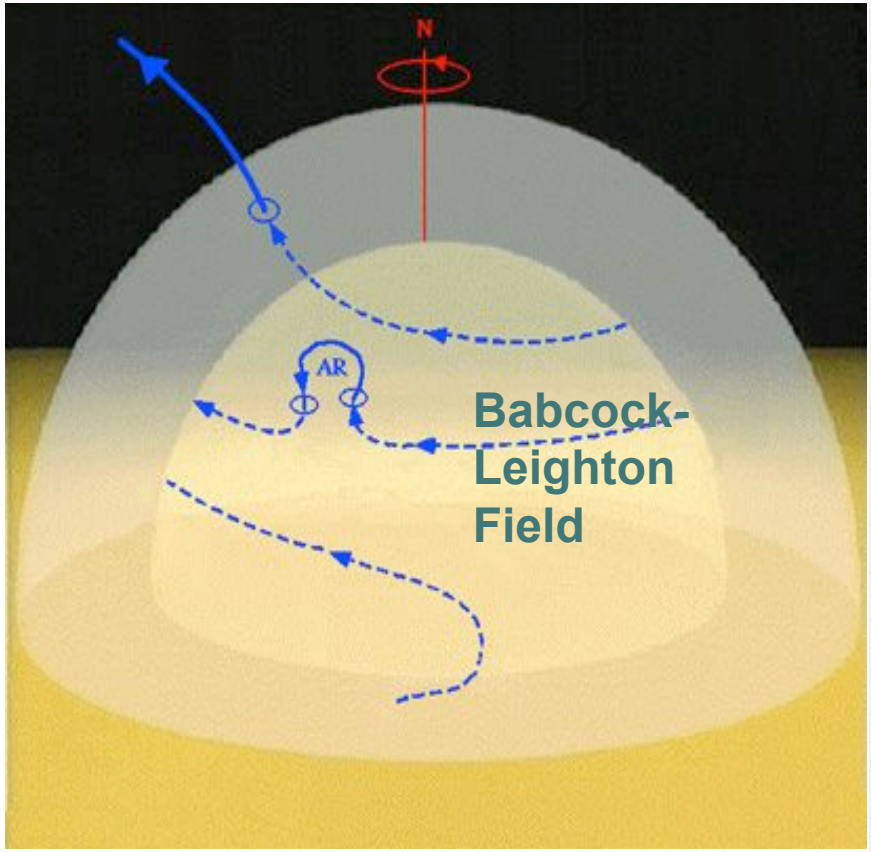
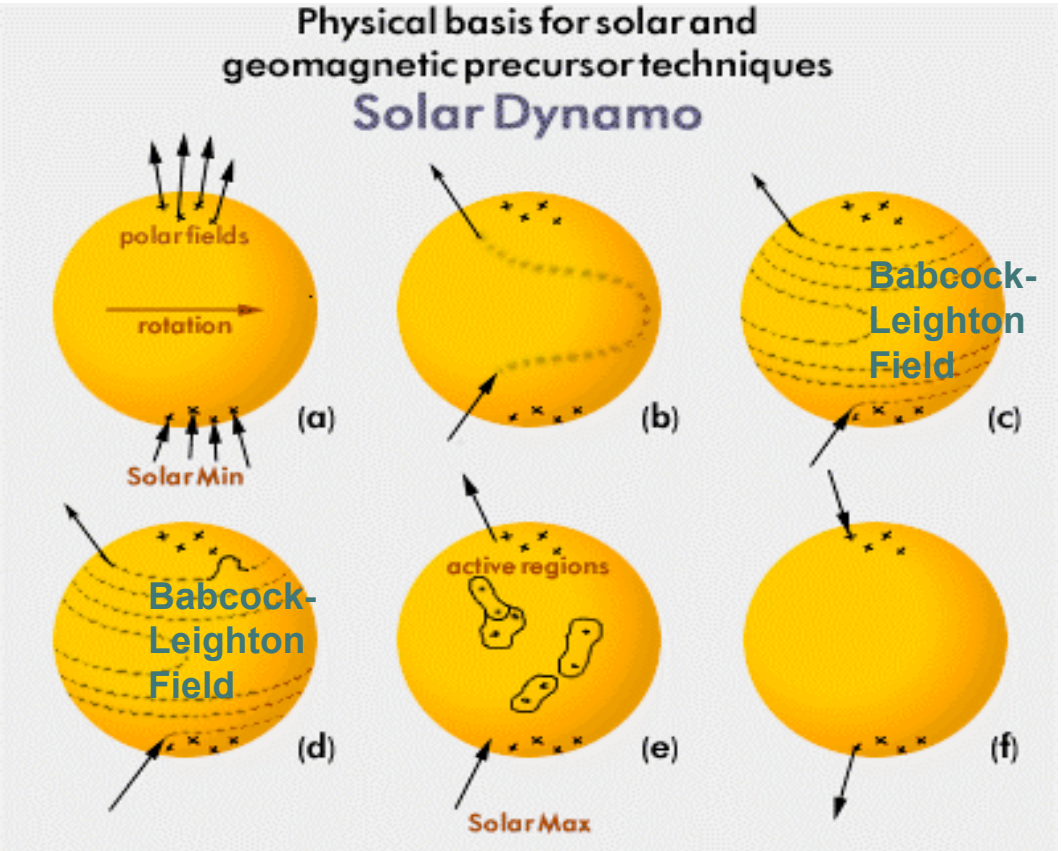
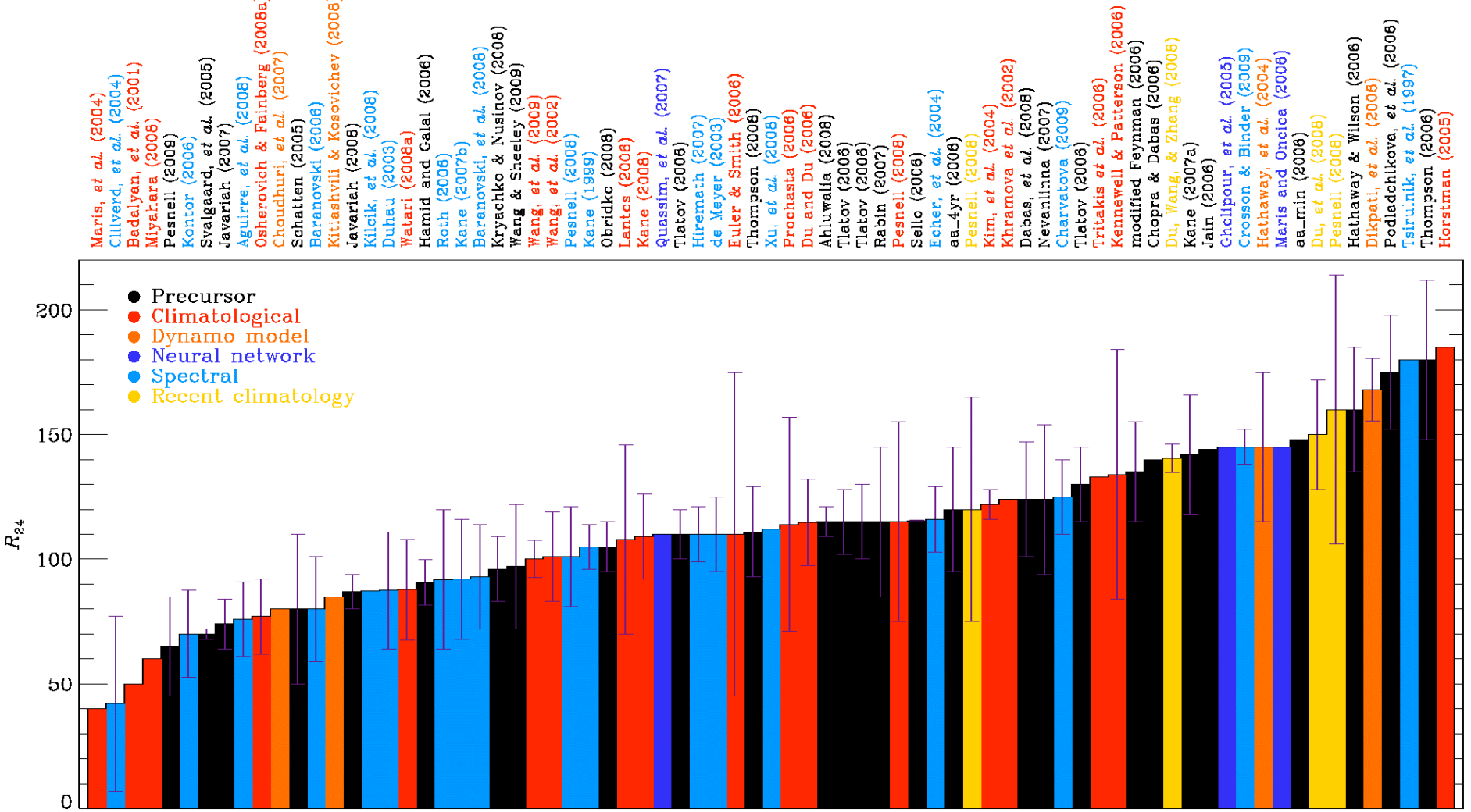
POLAR FIELD PRECURSOR METHOD

- DOES **NOT** DEPEND ON SHALLOW VS DEEP SOURCE OF DYNAMO.
- BABCOCK-LEIGHTON ORIGINAL VIEW WAS SHALLOW
- DYNAMO MOVED TO BOTTOM CZ
- BOTH: POLAR B =>TOROIDAL B and TOROIDAL B => POLAR B





How Active Will Solar Cycle 24 Be?



PESNELL : Our lack of knowledge about the dynamo is summarized by the spread of predictions for Cycle 24

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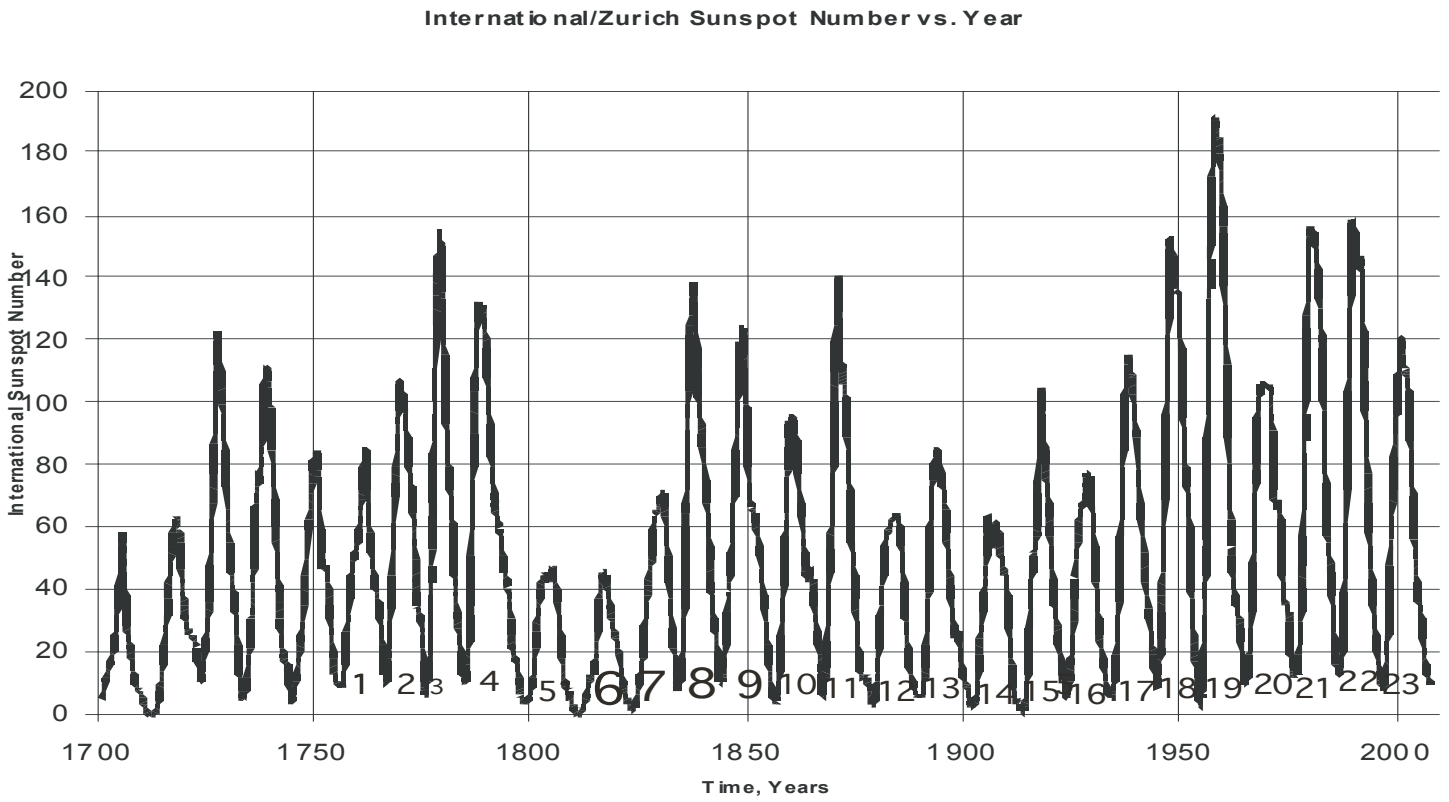
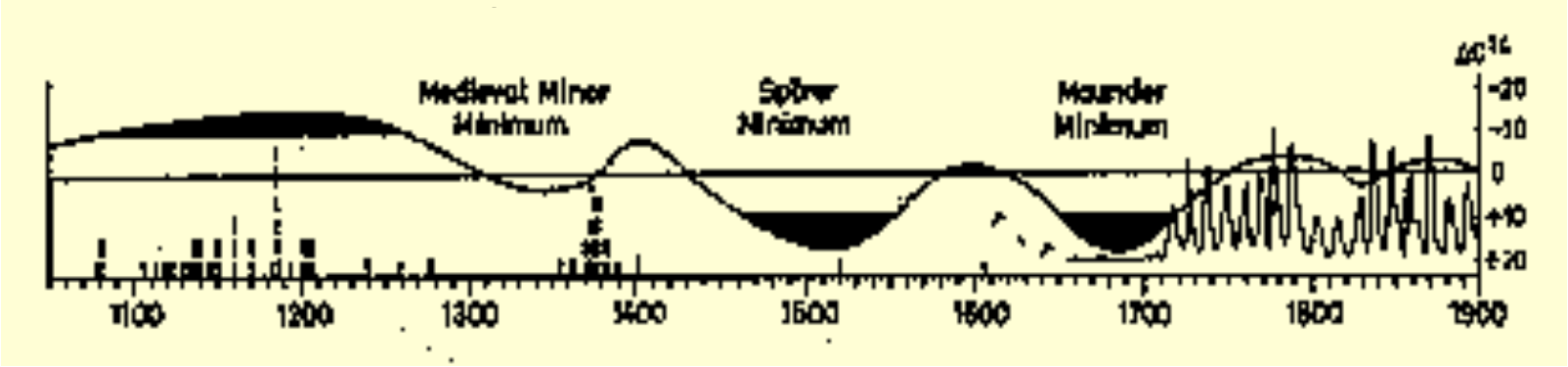
SOLAR ACTIVITY OBSERVATIONS: PREDICTION DIFFICULT





GEOMAGNETIC PRECURSORS: AN OFFSHOOT SINCE POLAR FIELD AFFECTS INTERPLAN. FIELD & EARTH

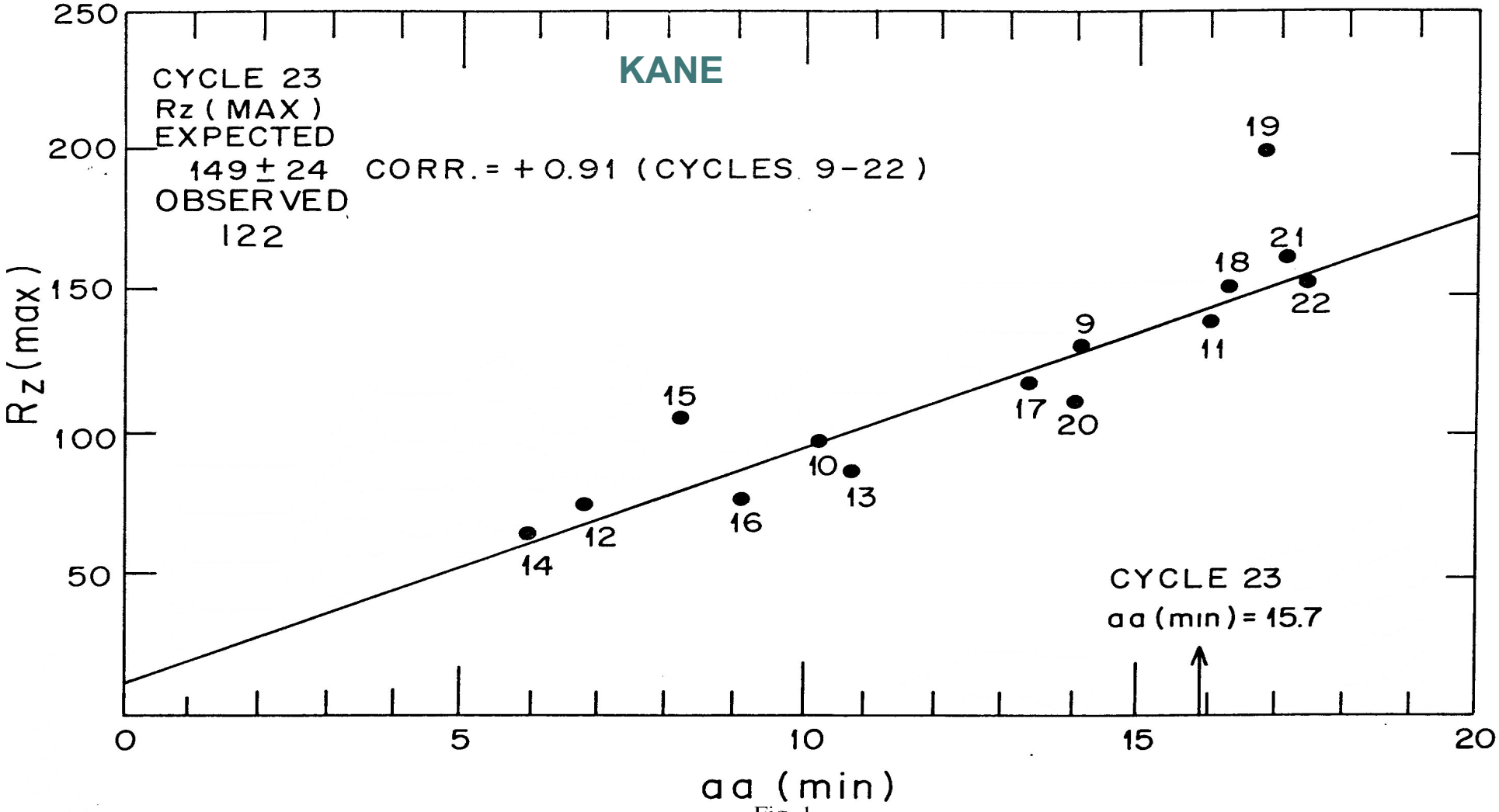
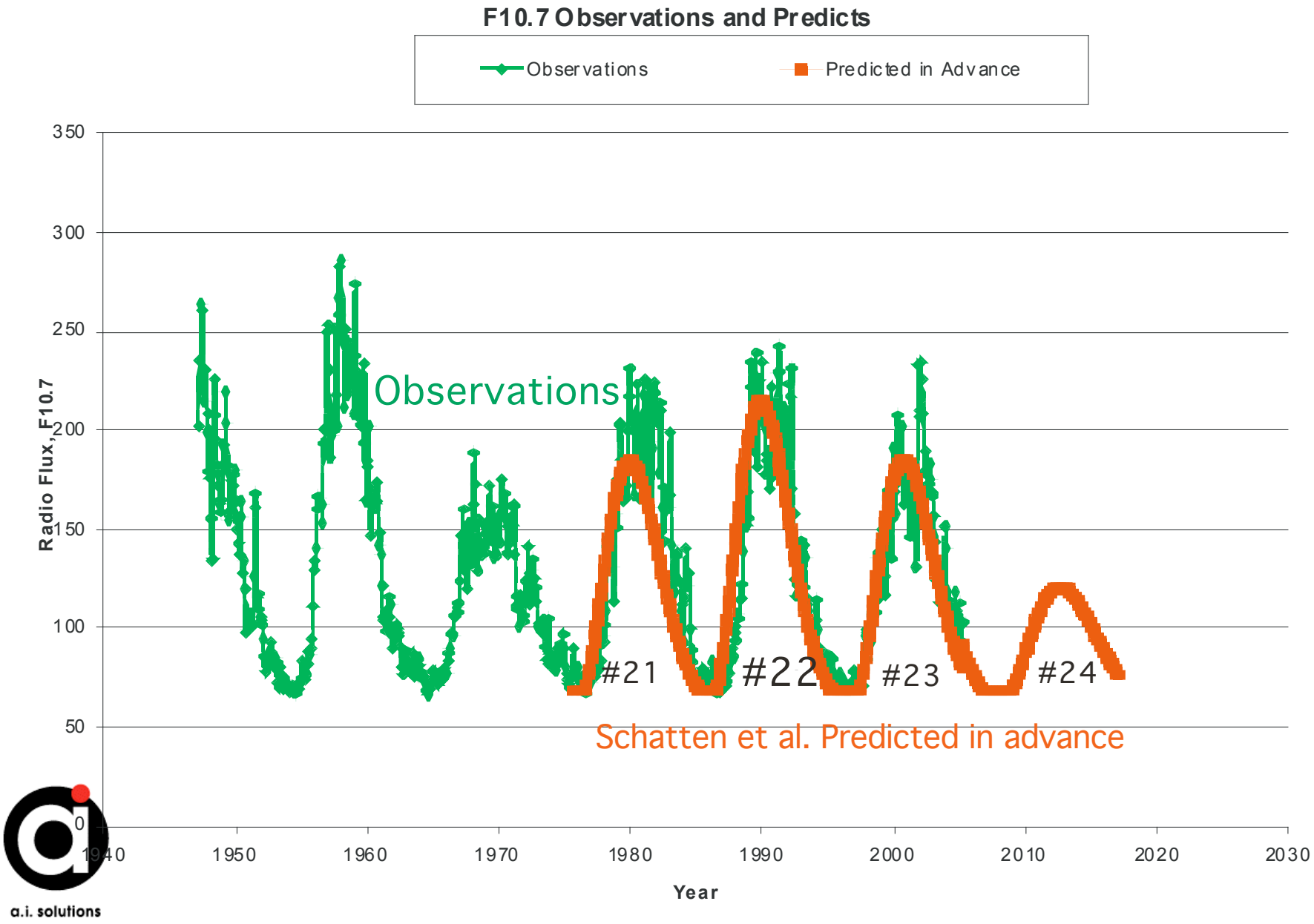


Fig. 1

Polar Field Precursor Predictions



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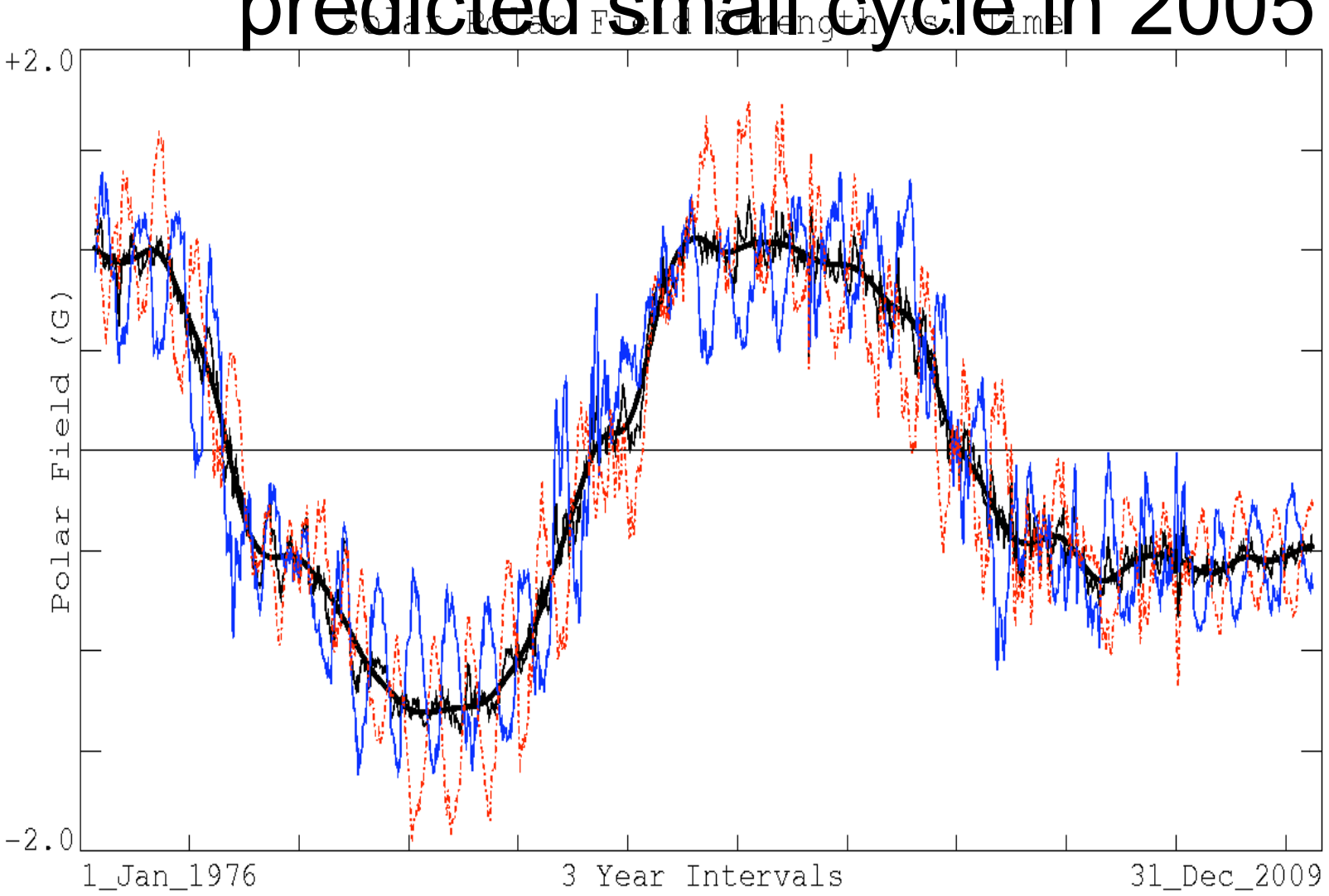
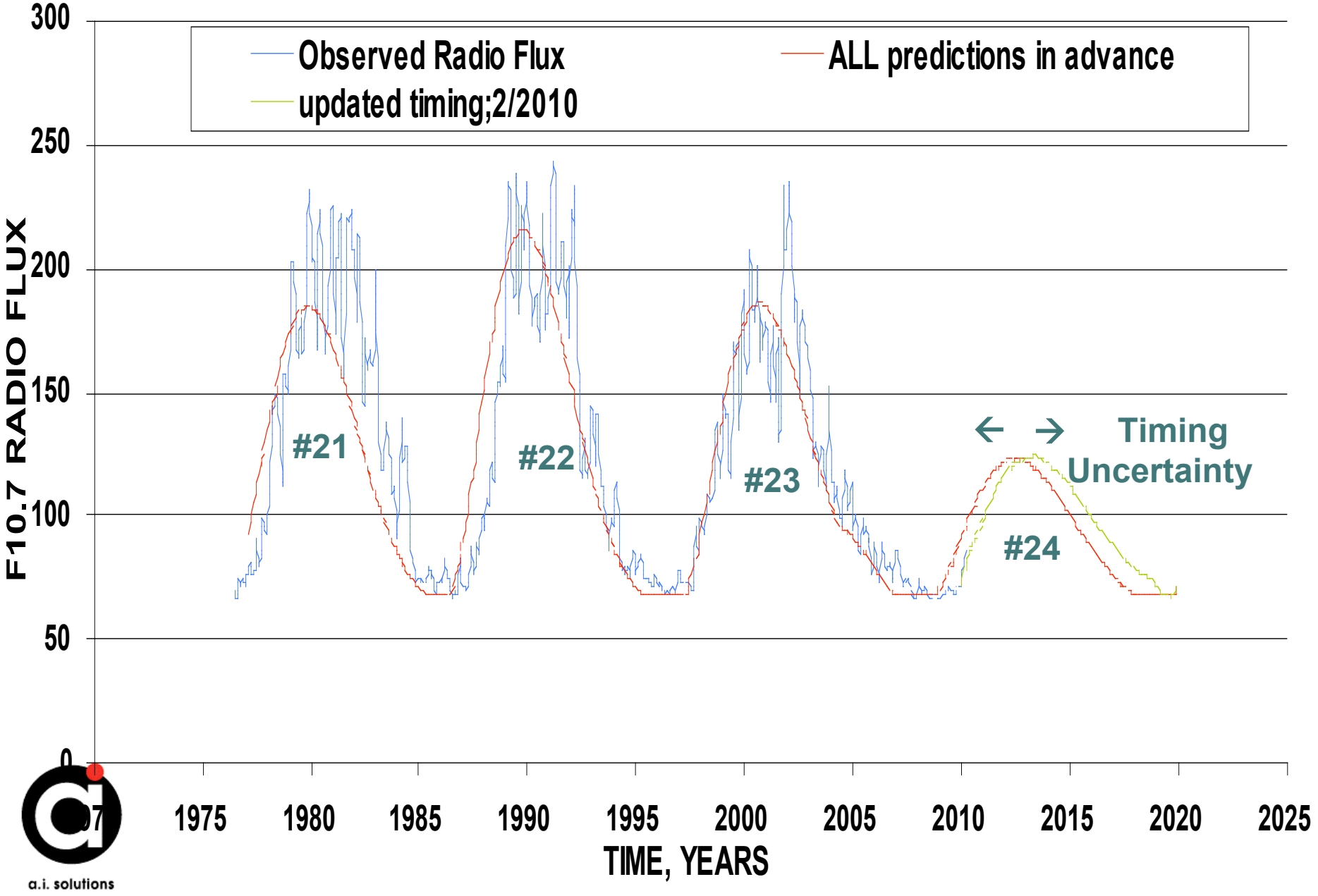
Polar Field Shows Marked Decrease in 2003+, which is why we and Svalgaard predicted small cycle in 2005



Observed and Predicted Radio Flux, F10.7



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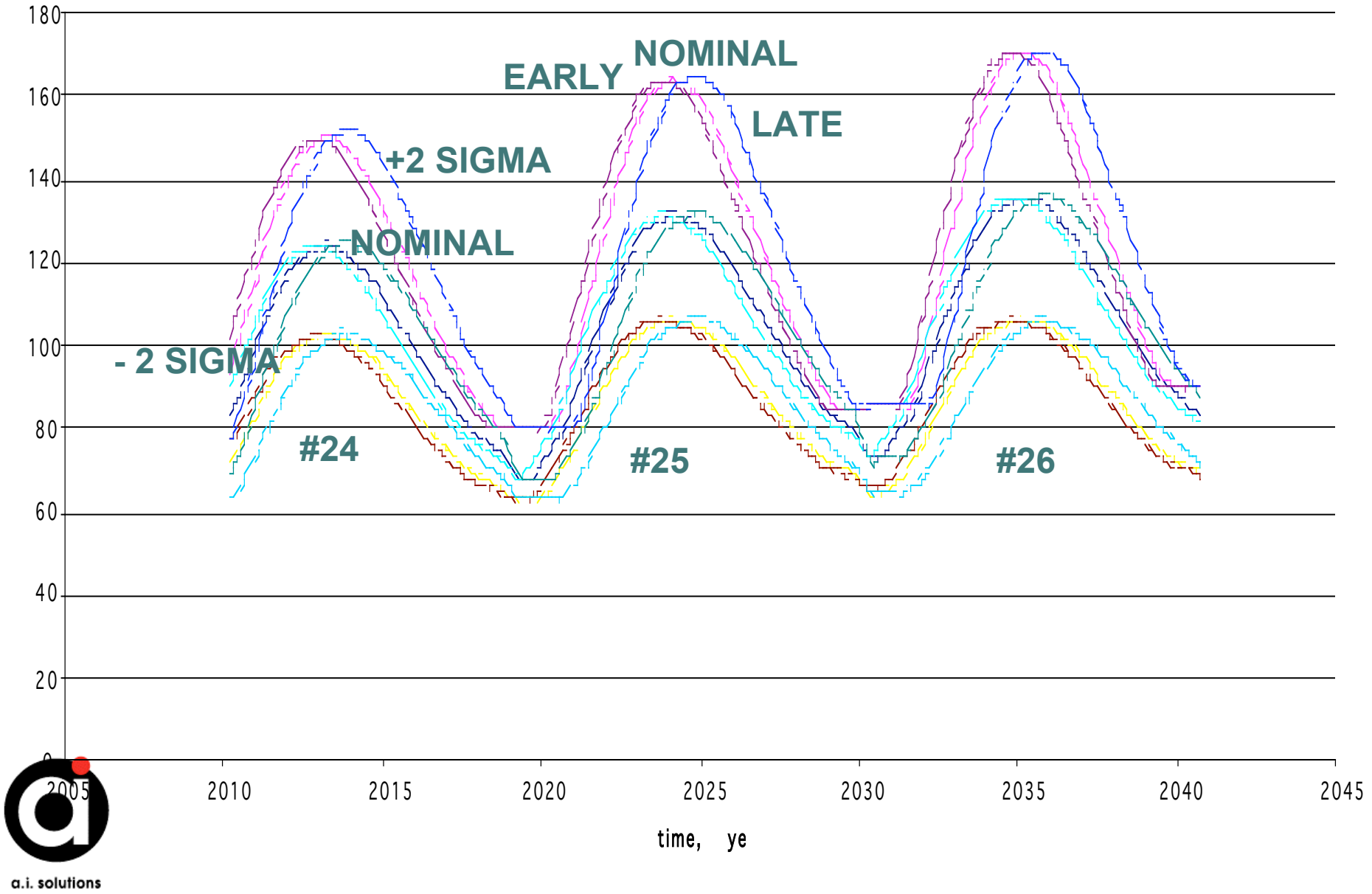
Predictions and +-2 SIGMA Ordinate and Timing uncertainties
180
160
140
120
100
80
60
40
20
0
2005
2010
2015
2020
2025
2030
2035
2040
2045
time, ye
EARLY
NOMINAL
LATE
+2 SIGMA
NOMINAL
- 2 SIGMA
#24
#25
#26
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Shallow Solar Dynamo -Percolation

- Introduction and Overview
- Ion Hurricane Mechanism – In- & Down-flows below spots gather neutral H & field below spots. Similar to how water vapor is gathered into clouds in the outer vortex of a terr. hurricane.
- Lockheed Group's view of Ephemeral Active Regions (EPRs), (X-ray Bright Points) and the Corona
- Percolation –EPRs may gather into spots, under special conditions – high S and large horizontal B.
- The Solar Dynamo & Cellular Automata Modeling

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INTRODUCTION

- Percolation comes from Percolare to Filter/Strain may also be called clustering – gathering together.
- Act.Region Percolation began w. Seiden & Wentzel. Ruzmaikin said magnetic field clusters. Brandenburg also considered a shallow solar dynamo.
- Overall, our Model represents a non-linear magnification of small scale fields near the Sun's surface to gather (percolate) to form Active Regions.
- Toroidal (Babcock-Leighton) fields are formed by Differential Rot. of Poloidal field. This subsurface B-Field helps percolation to form AR's; when they break up, they migrate towards the poles

OVERVIEW

- LARGE FIELDS RESULT WHEN LIKE-SIGN EPR Bs GATHER & DIFFUSE: INVERSE CASCADE
- B FIELDS MOVE ON THE SUN'S SURFACE –DRIVEN BY SUBSURFACE MAG. FORCES, MERID. FLOW + D.ROT: NOT SOLELY DIFFUS.
- B IS BUOYANT: EVADES ↓ DESCENDING
- HOW FIELDS FORM SPOTS AND FACULAE
- ROLE OF S TO ACTIVE REGIONS, FIELD, ETC.
- MODELING EFFORTS: CELLULAR AUTOMATA

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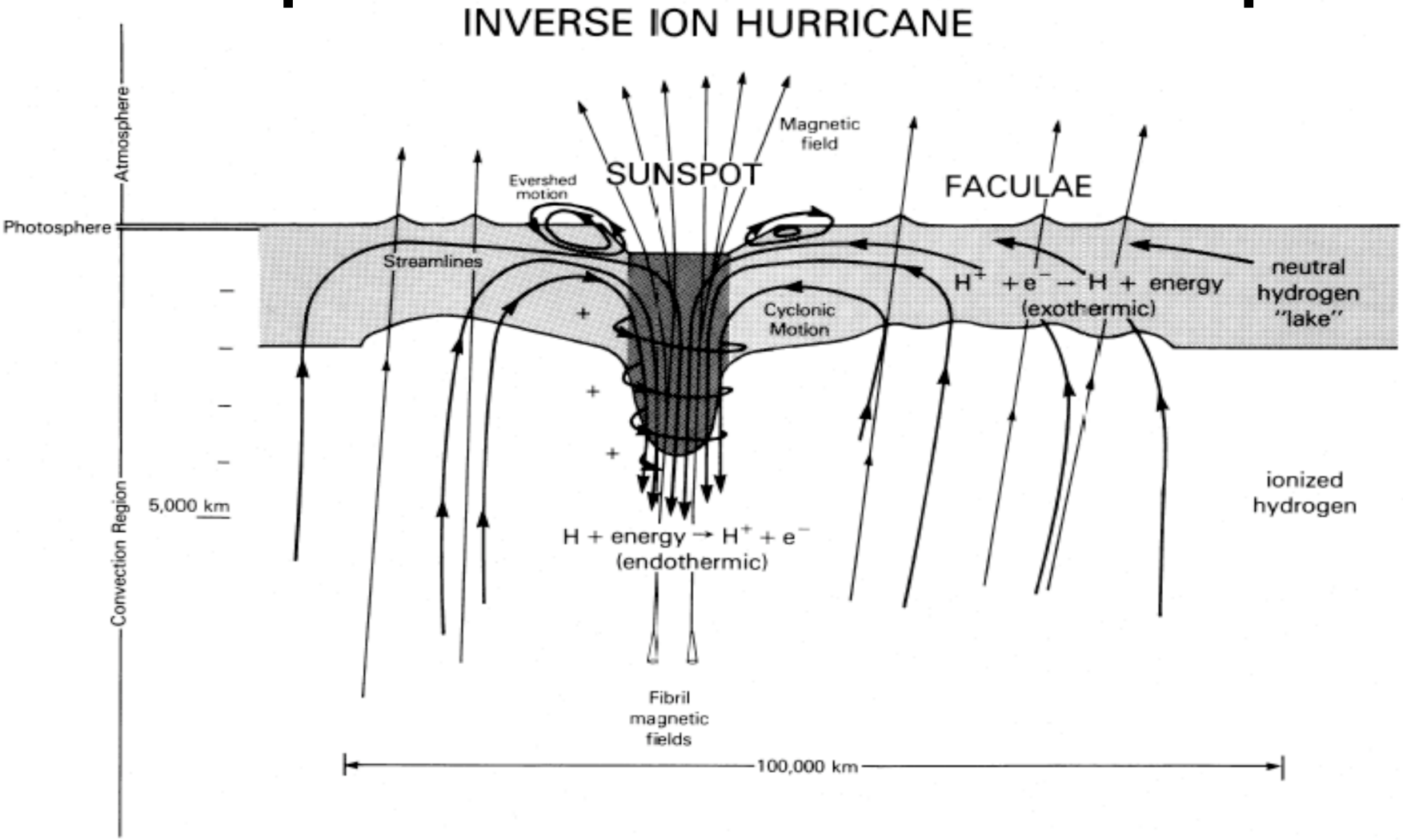
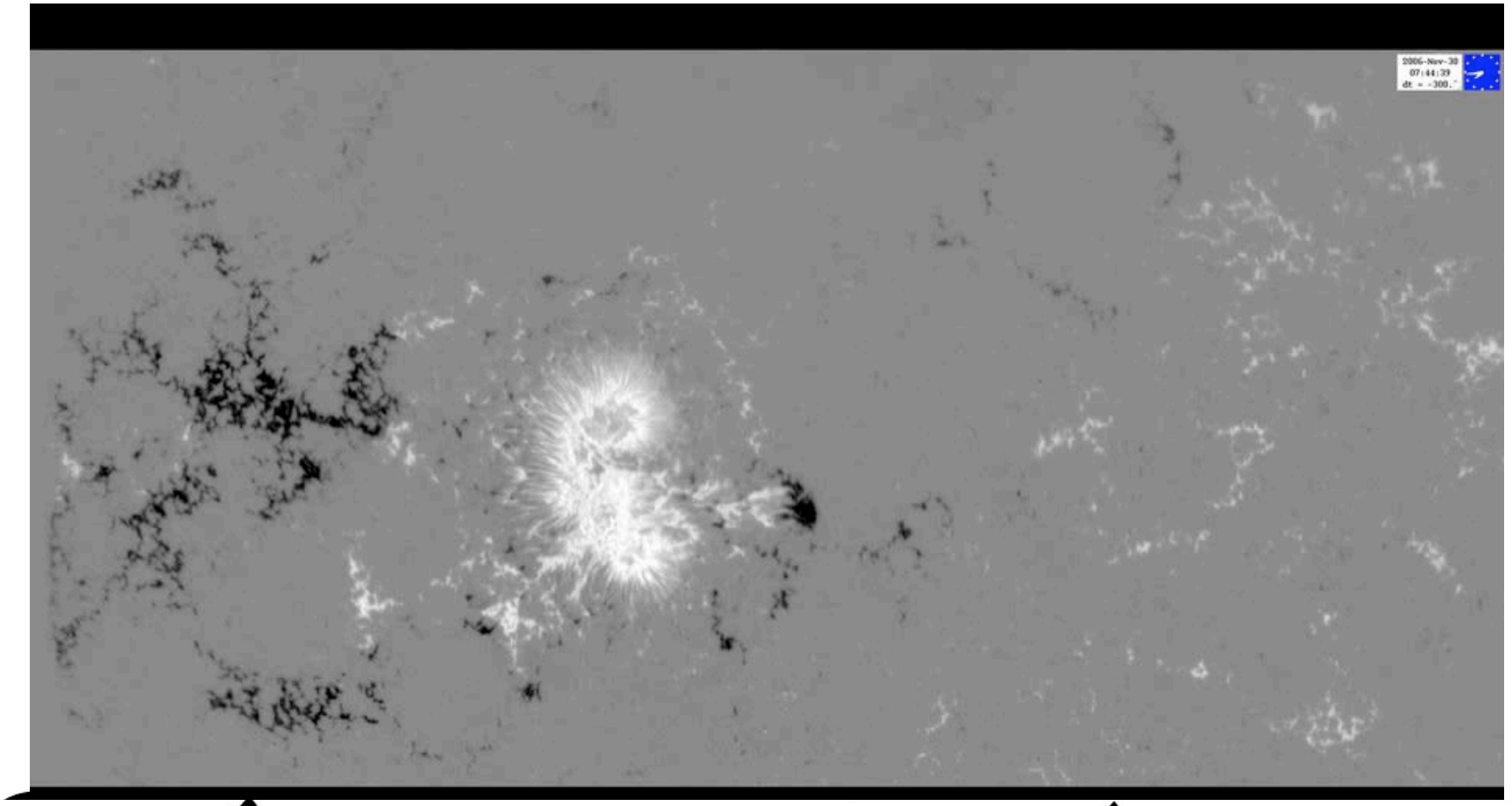
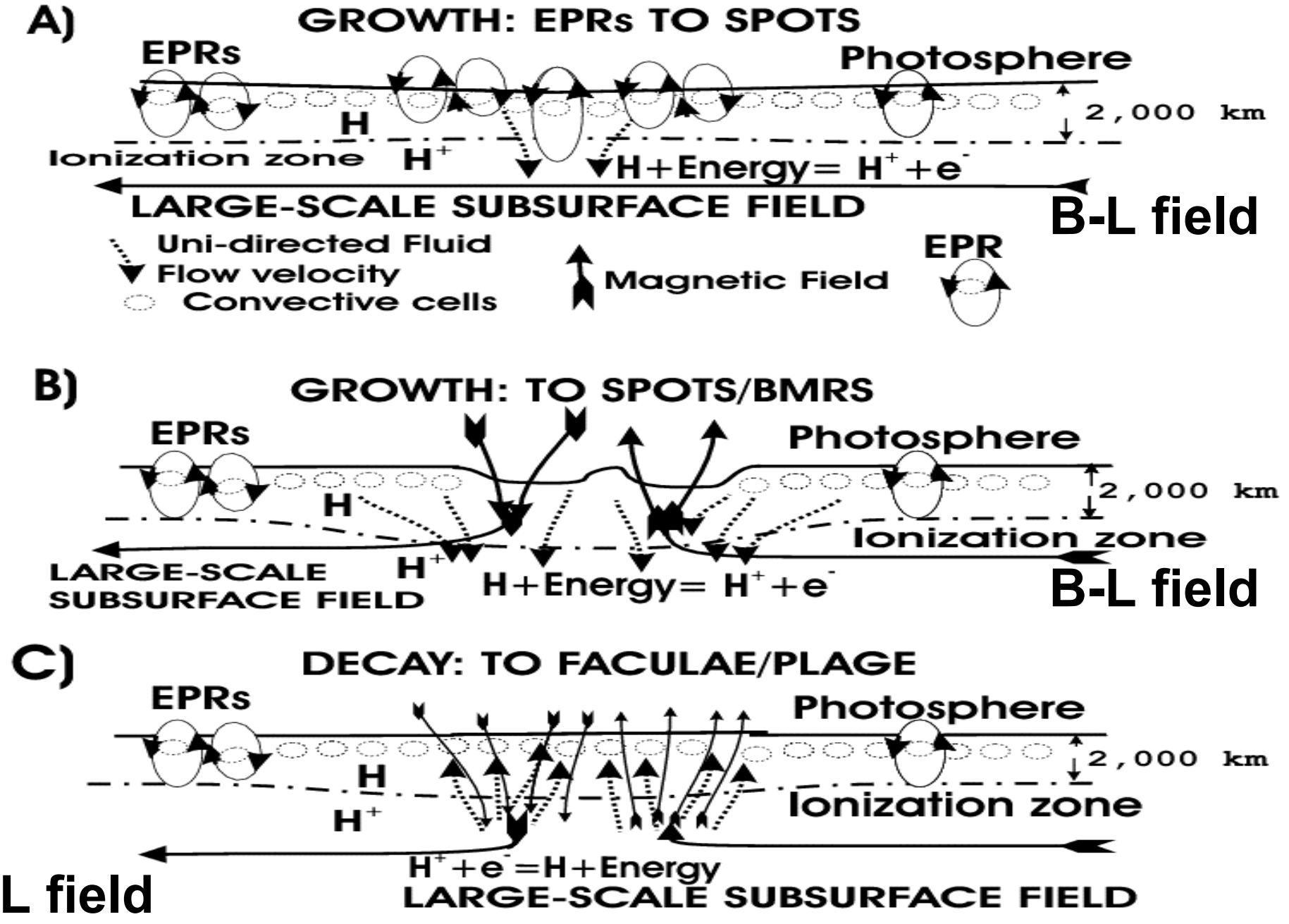
Schatten&Mayr: Shallow Surface Layers: S large; latent energy (H to H^+) available; convective collapse (Zwaan,Parker) occurs/process allows field to form spots.



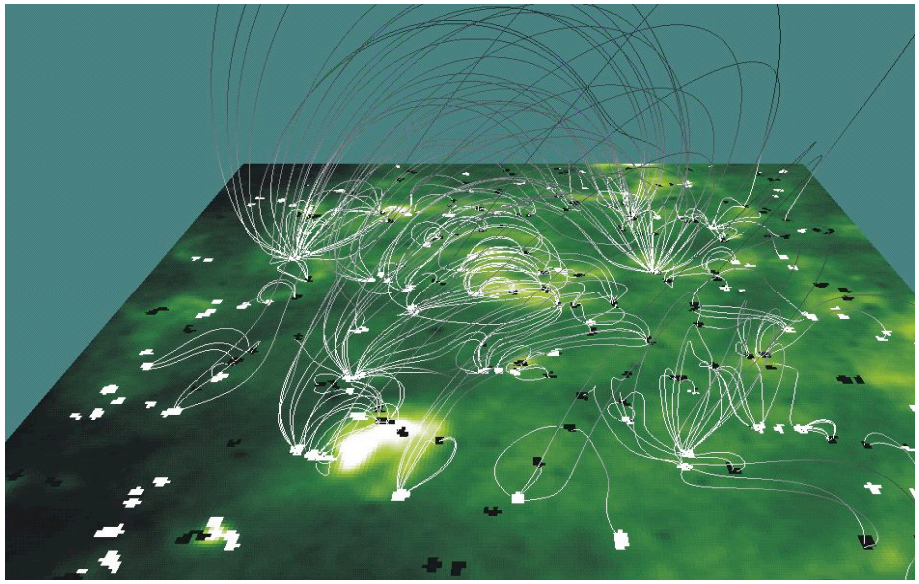
New Region: Like Fields Move Together (White=>White)

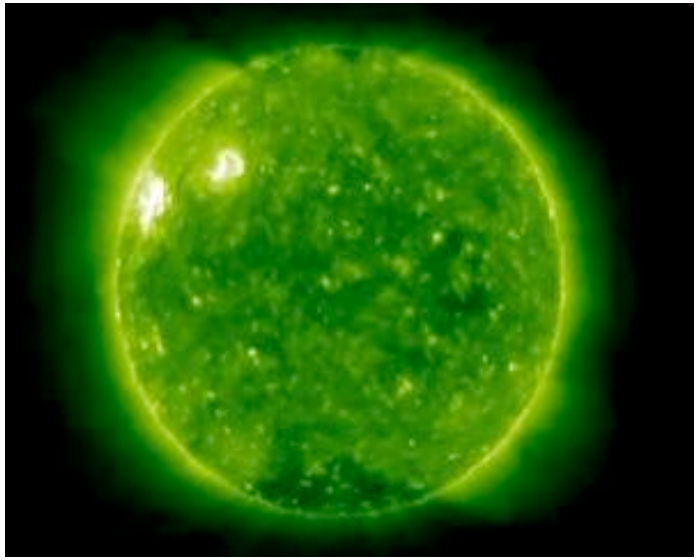


SUPERADIABATIC PERCOLATION



Lockheed Group-Magnetic Carpet:EPRs Conv.Collapse of Fibrils: Percolation





12/2008
EIT/SOHO
EXTREME
UV
IMAGING

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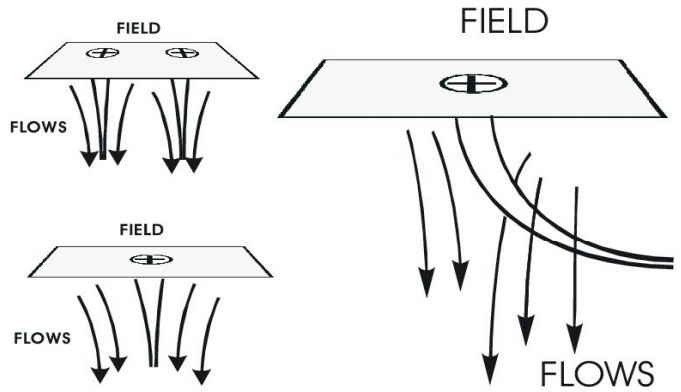
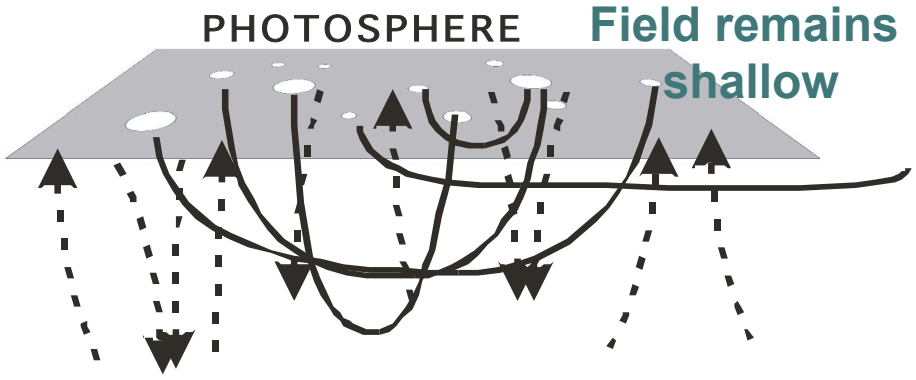
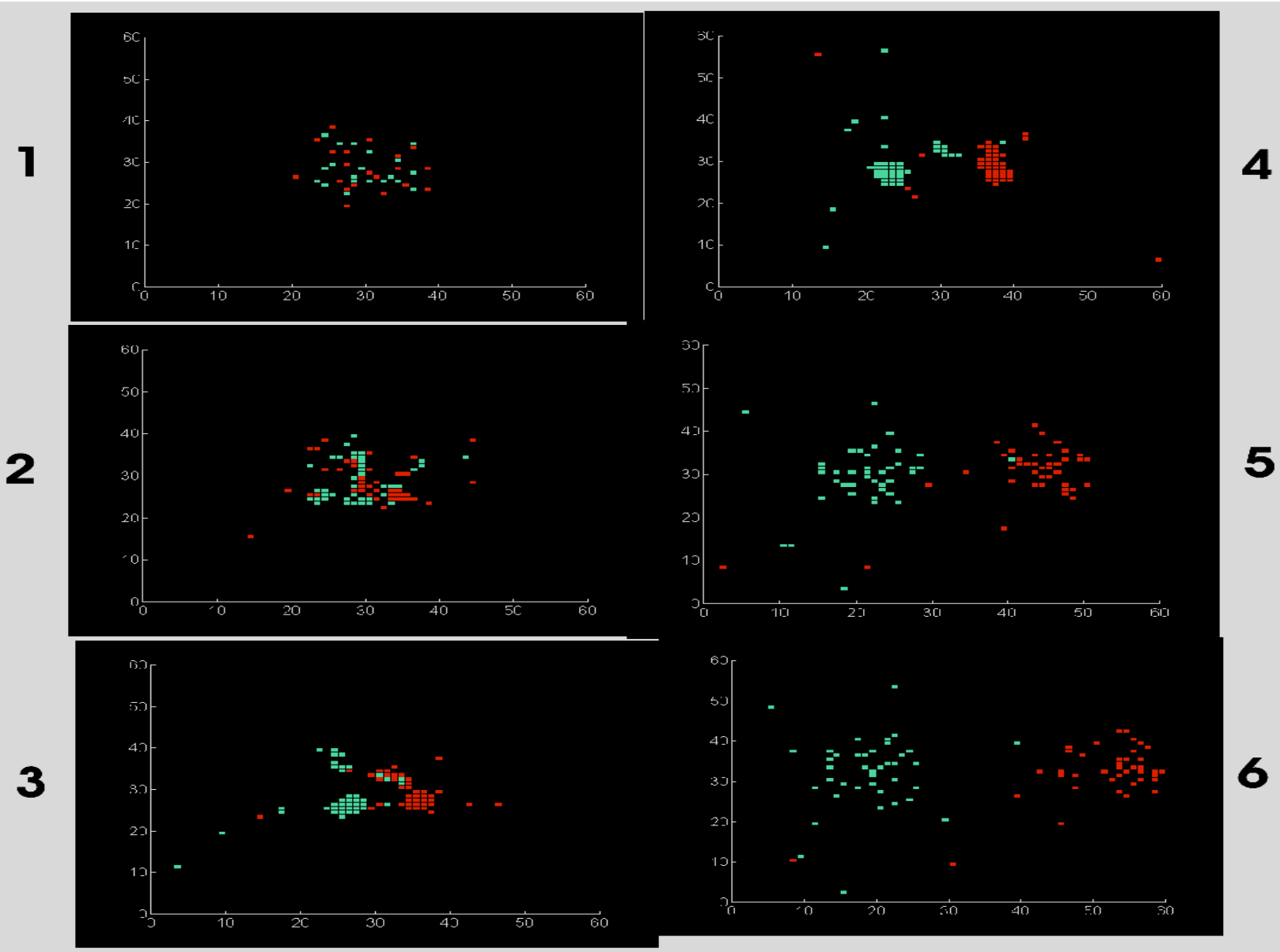
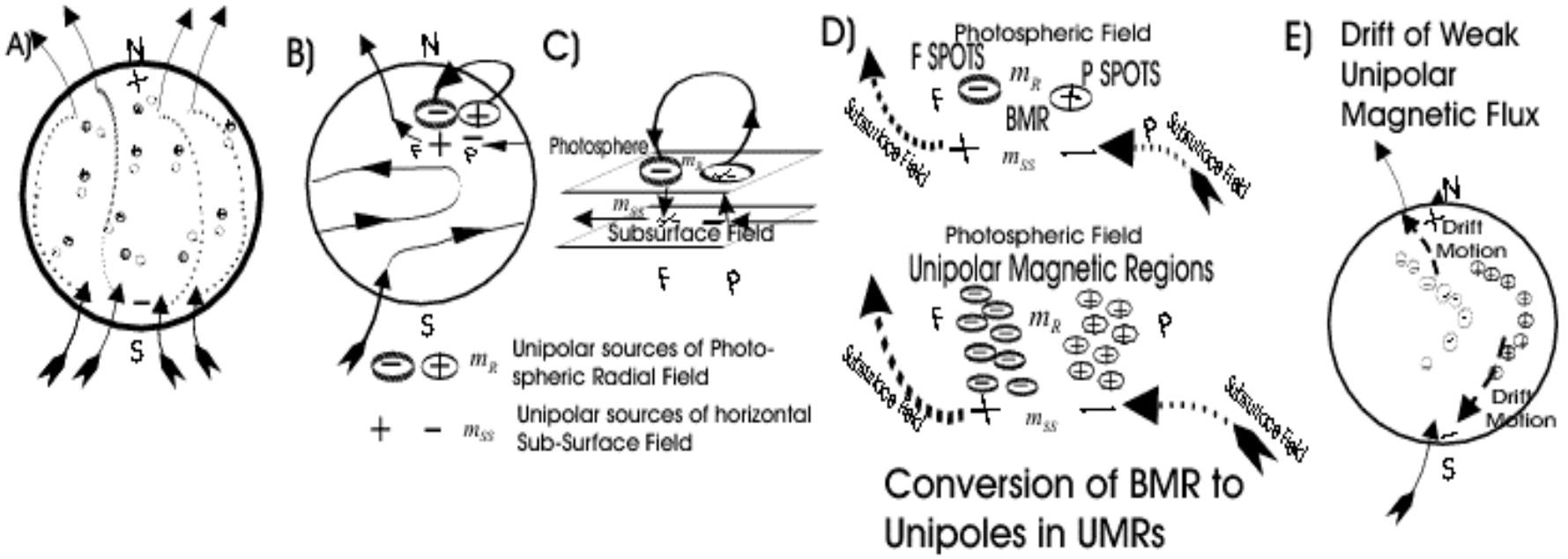






Superadiabatic Percolation, Field Drift, and Normal Percolation into Unipolar Magnetic Regions (UMRs)

3D VIEW:Shallow Dynamo-B moves by B TENSION (=mB), not diffusion

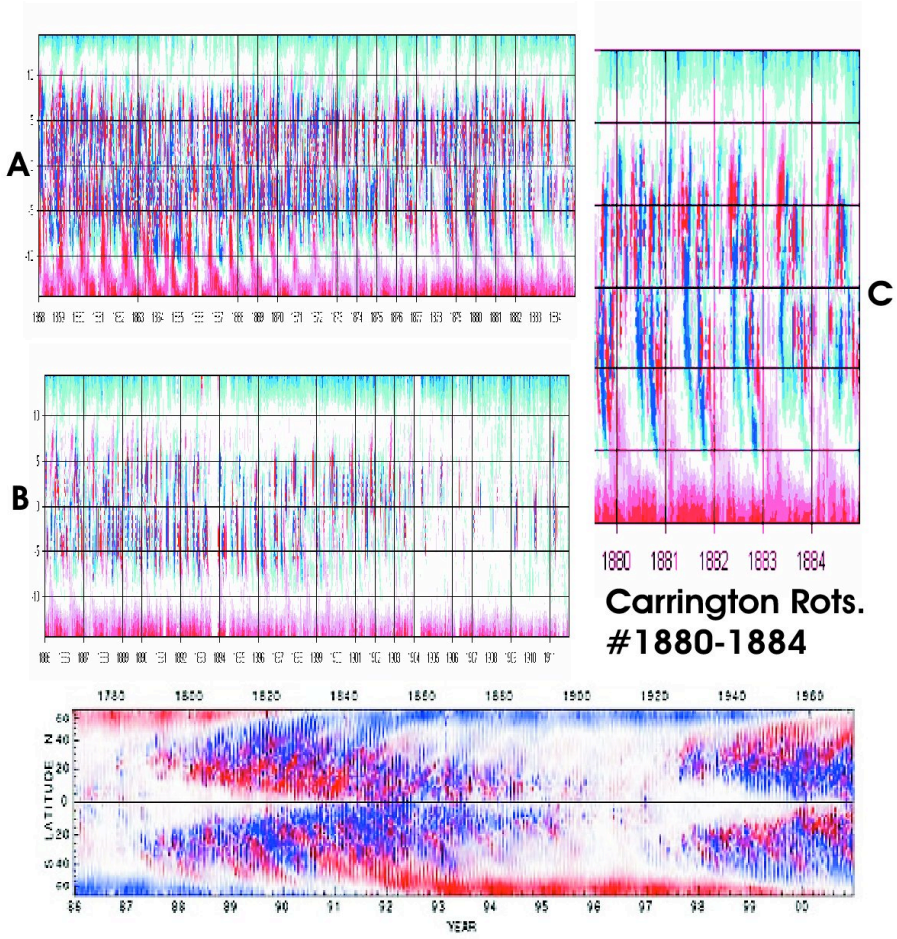


Development of Fields During an Odd # Cycle:

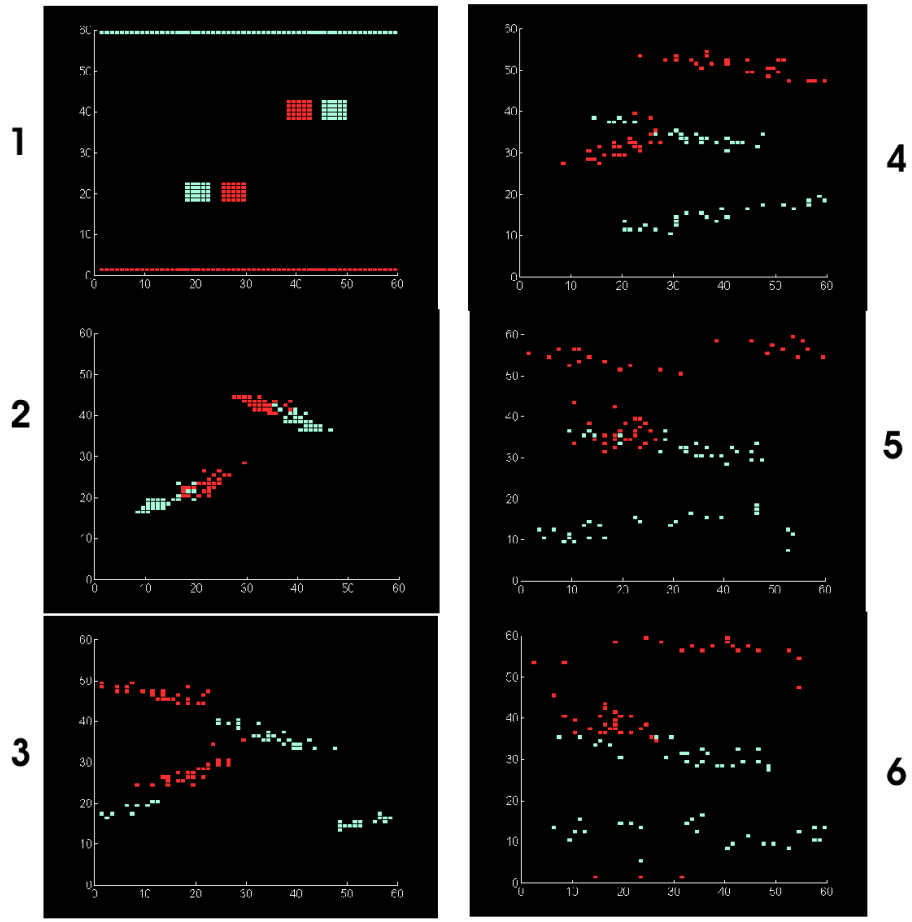
NH Following Flux=>NH pole; NH Preceding Flux=>SH pole

Vice Versa for SH Fluxes, and Even # Cycles

Large Scale Modeling and Observations (Ulrich and Boyden)



D SUPERSYNOPTIC & SYNOPTIC MAPS OF THE SUN'S MAGNETIC FIELDS : SOLAR CYCLE #22



MODELED BIPOLAR MAGNETIC REGIONS (BMRs): PERCOLATION WITH SUBADIABATIC GRADIENT+ DRIFT FROM DIPOLE FIELD + DIFFERENTIAL ROTATION

CONCLUSIONS-

- SOLAR PREDICTIONS BASED ON POLAR FIELDS – Have Predicted a SMALL CYCLE ~125 in F10.7 or ~75 Rz, PEAK ~ Early 2013. {GRL- 32, L21106 (2005)}.
- SHALLOW DYNAMO MAY BE POSSIBLE VIA PERCOLATION OR CLUSTERING; IN THE HIGHLY SUPERADIABATIC REGIONS OF THE OUTER SOLAR CZ, LIKE-SIGN FIELD ARE ATTRACTED BY NONLINEAR PROCESSES DRIVEN BY S. , ETC.

  {Sol. Phys., 255:3-38,2009}
- CELLULAR AUTOMATA ABLE TO MIMIC FEATURES OF SOLAR DYNAMO

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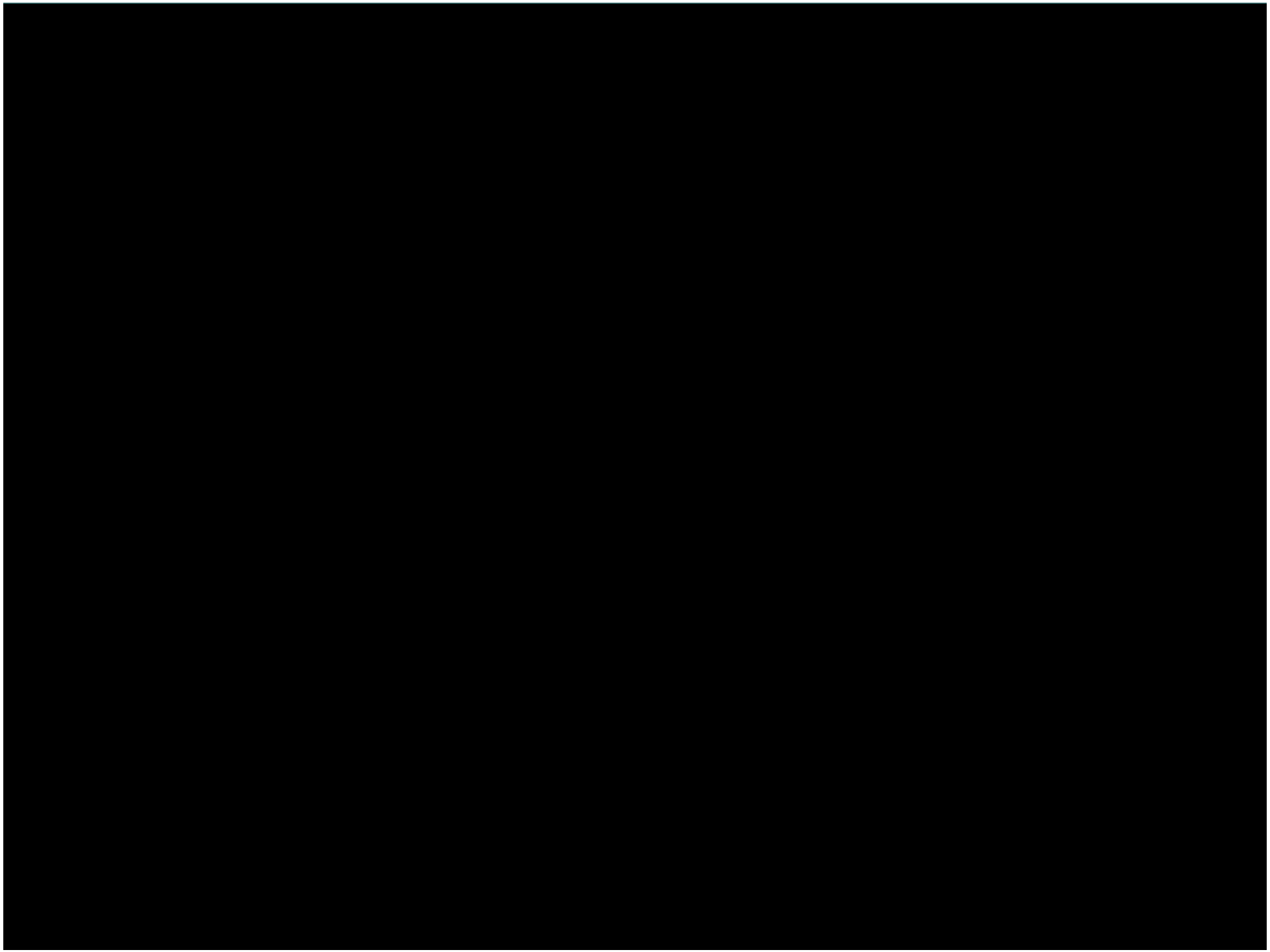
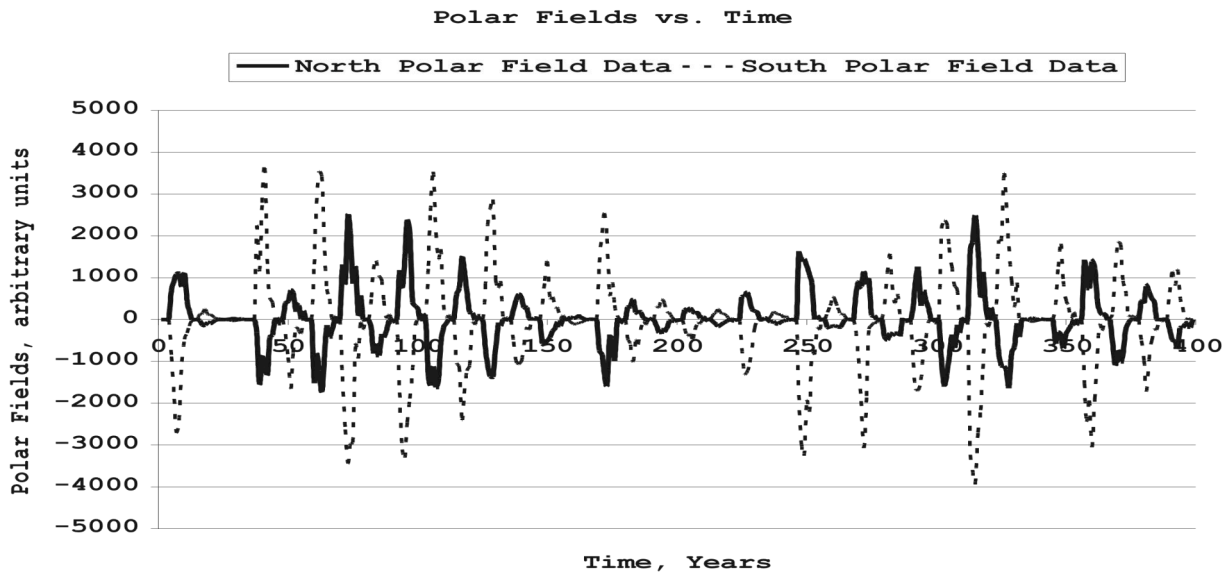
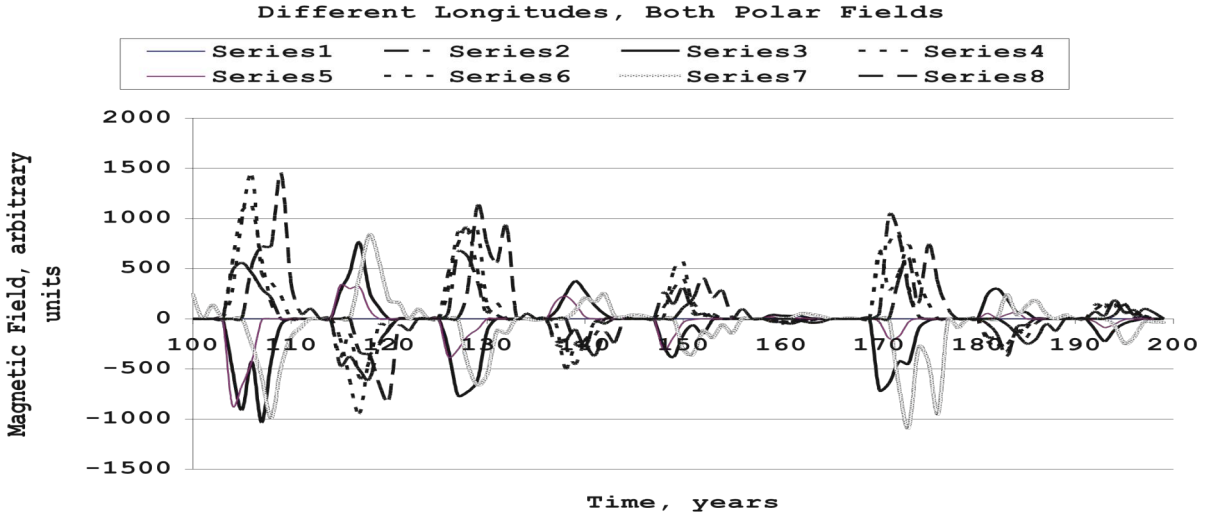


400 & 100 YR MODELING





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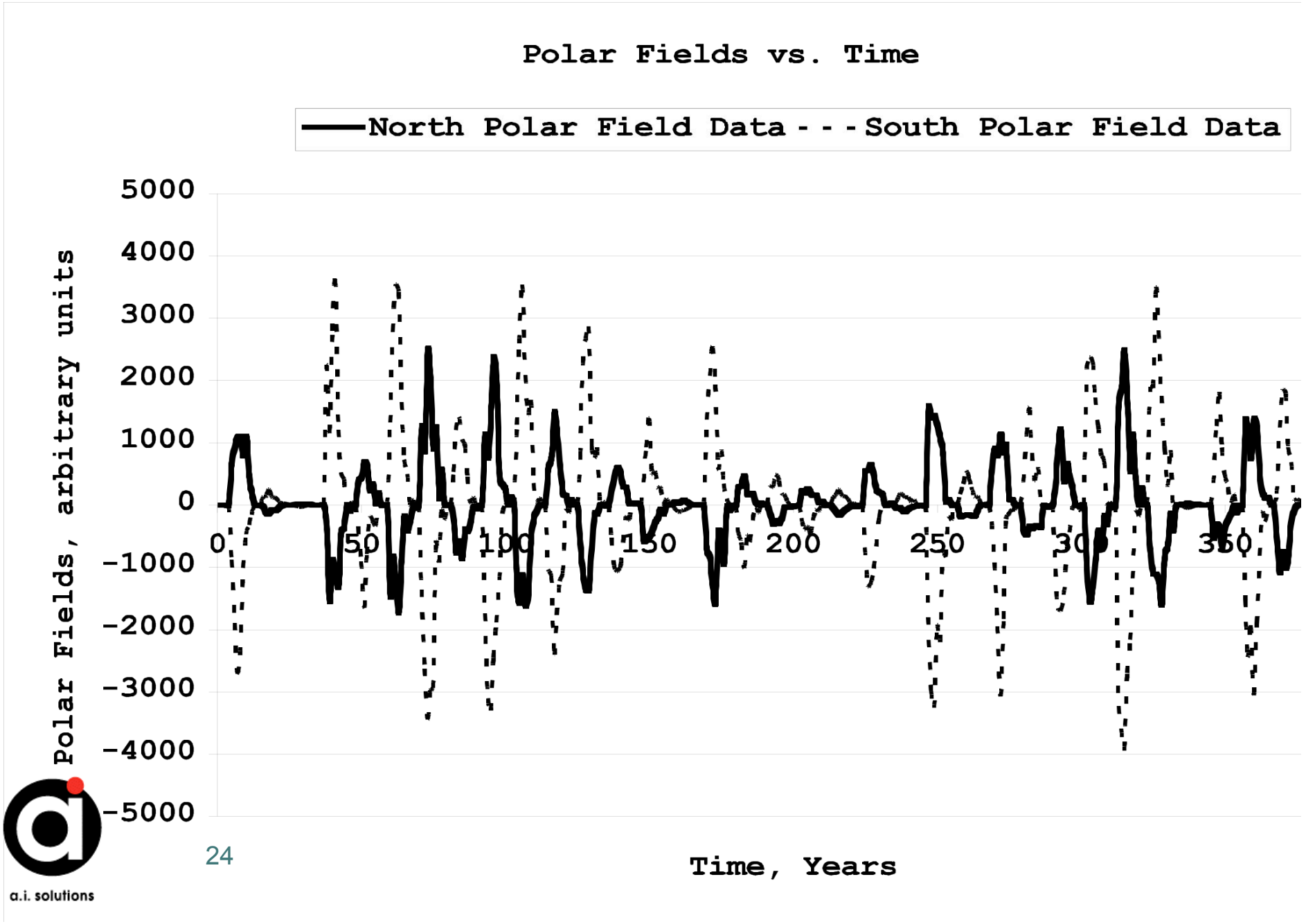

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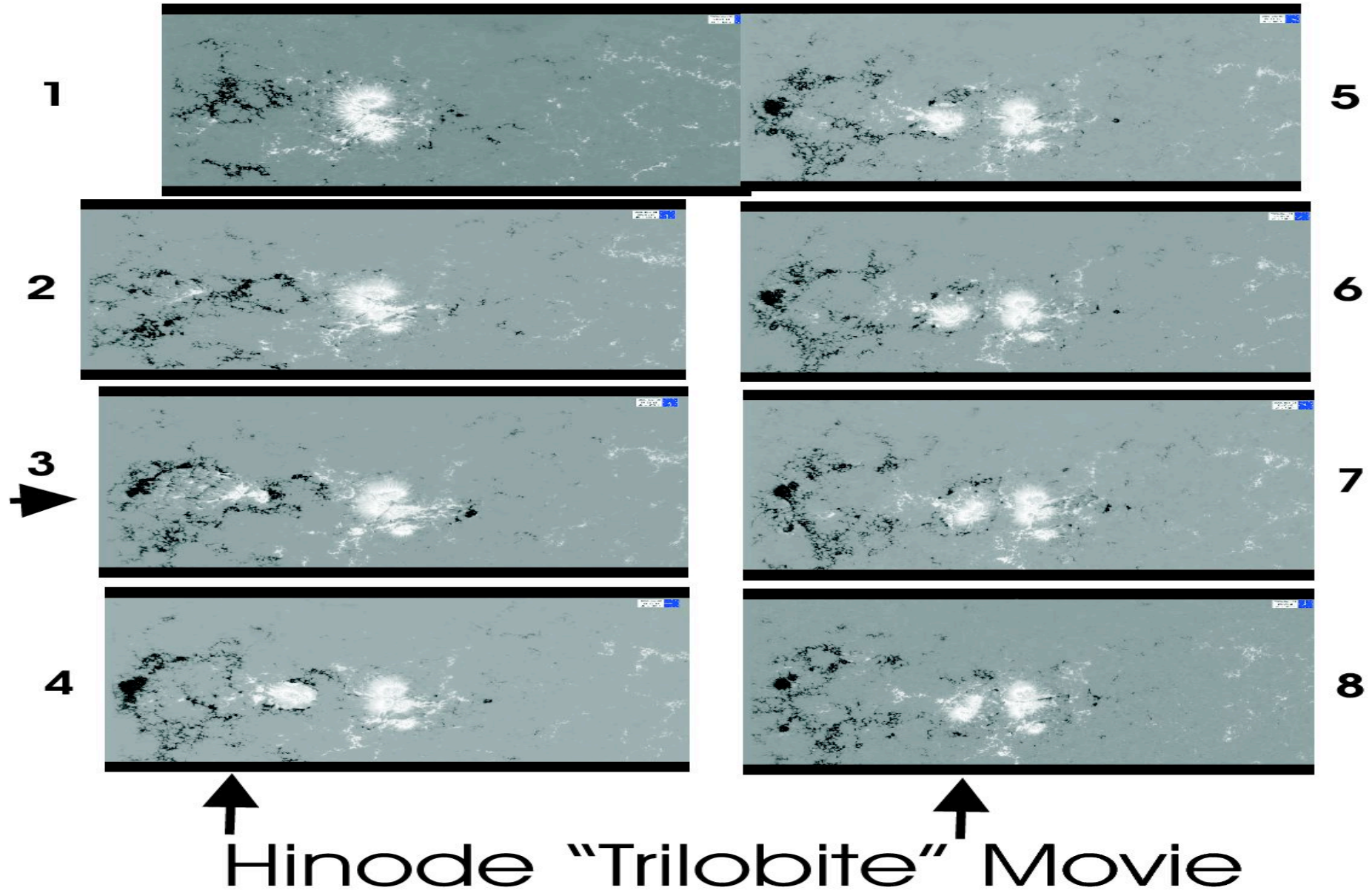

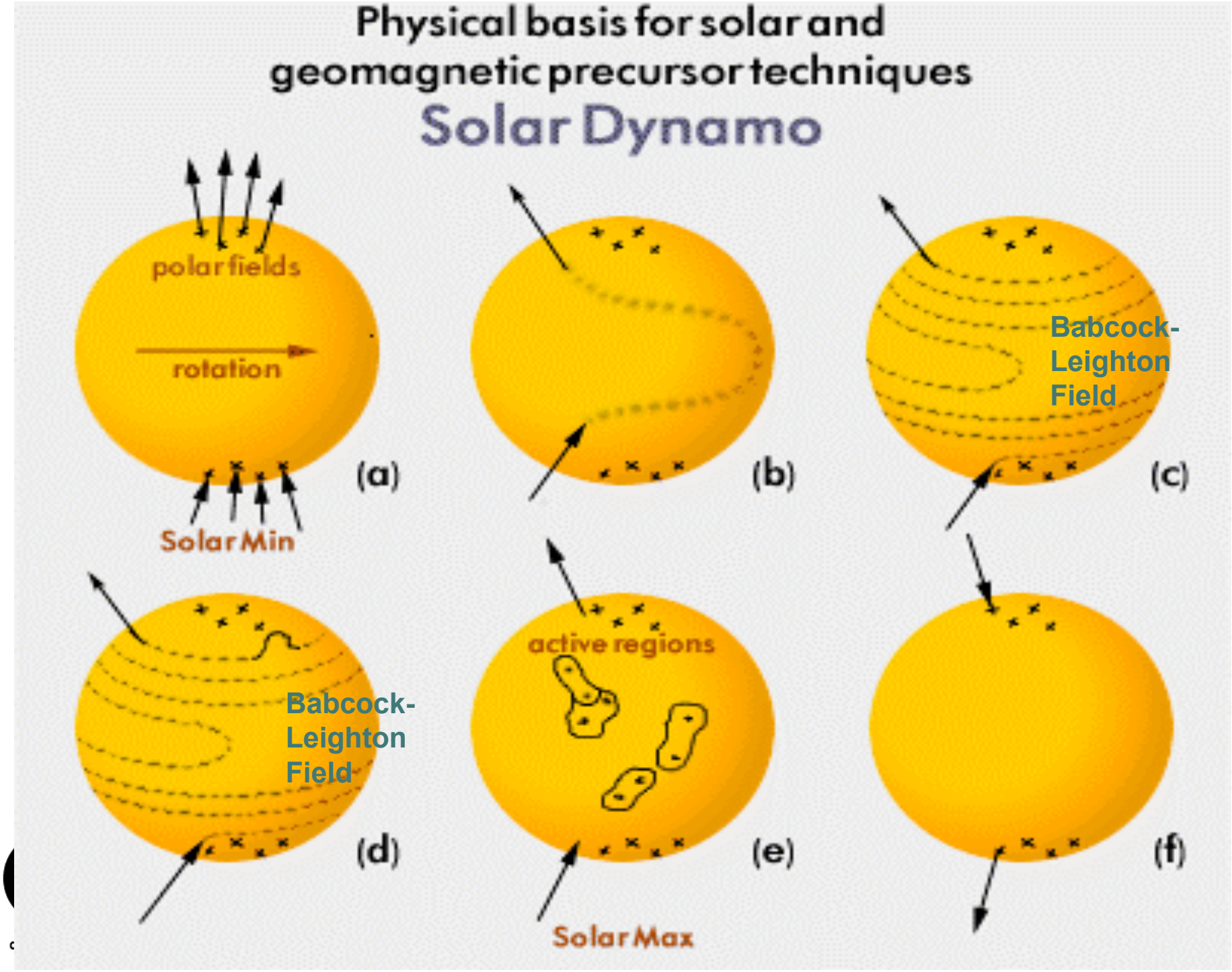
Physical basis for solar and geomagnetic precursor techniques
Solar Dynamo
polar fields
rotation
Solar Min
(a)
(b)
Babcock-Leighton Field
(c)
Babcock-Leighton Field
(d)
active regions
Solar Max
(e)
(f)