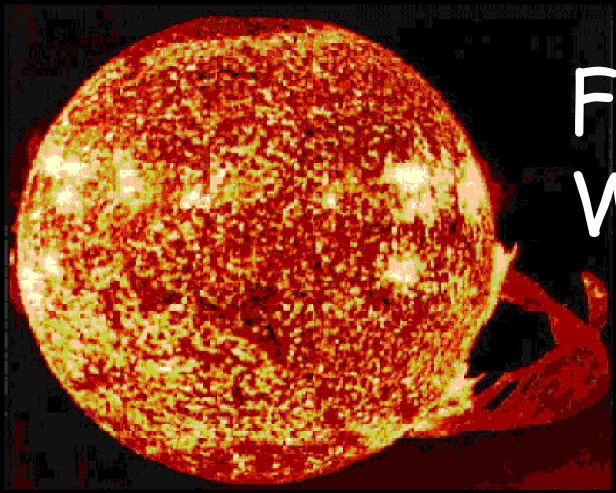


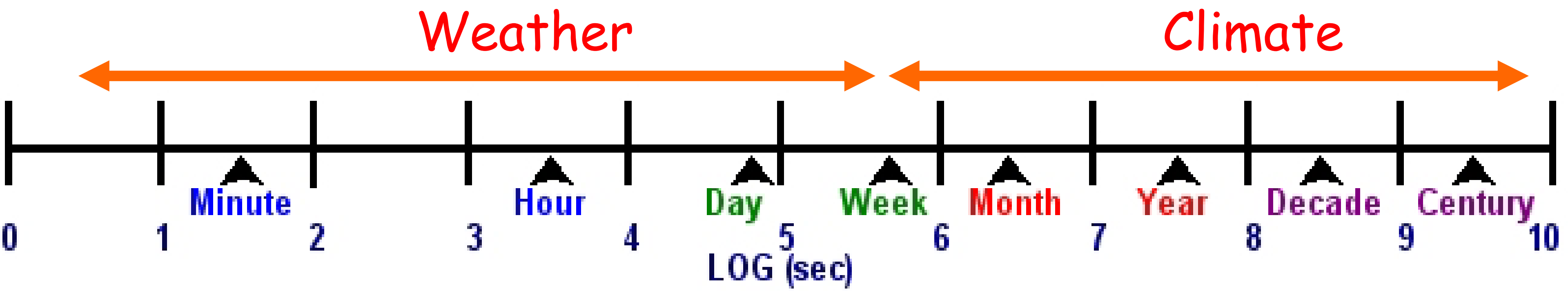
First European Space Weather Week

Space weather - atmospheres, drag, global change – future needs

29 November-3 December 2004

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

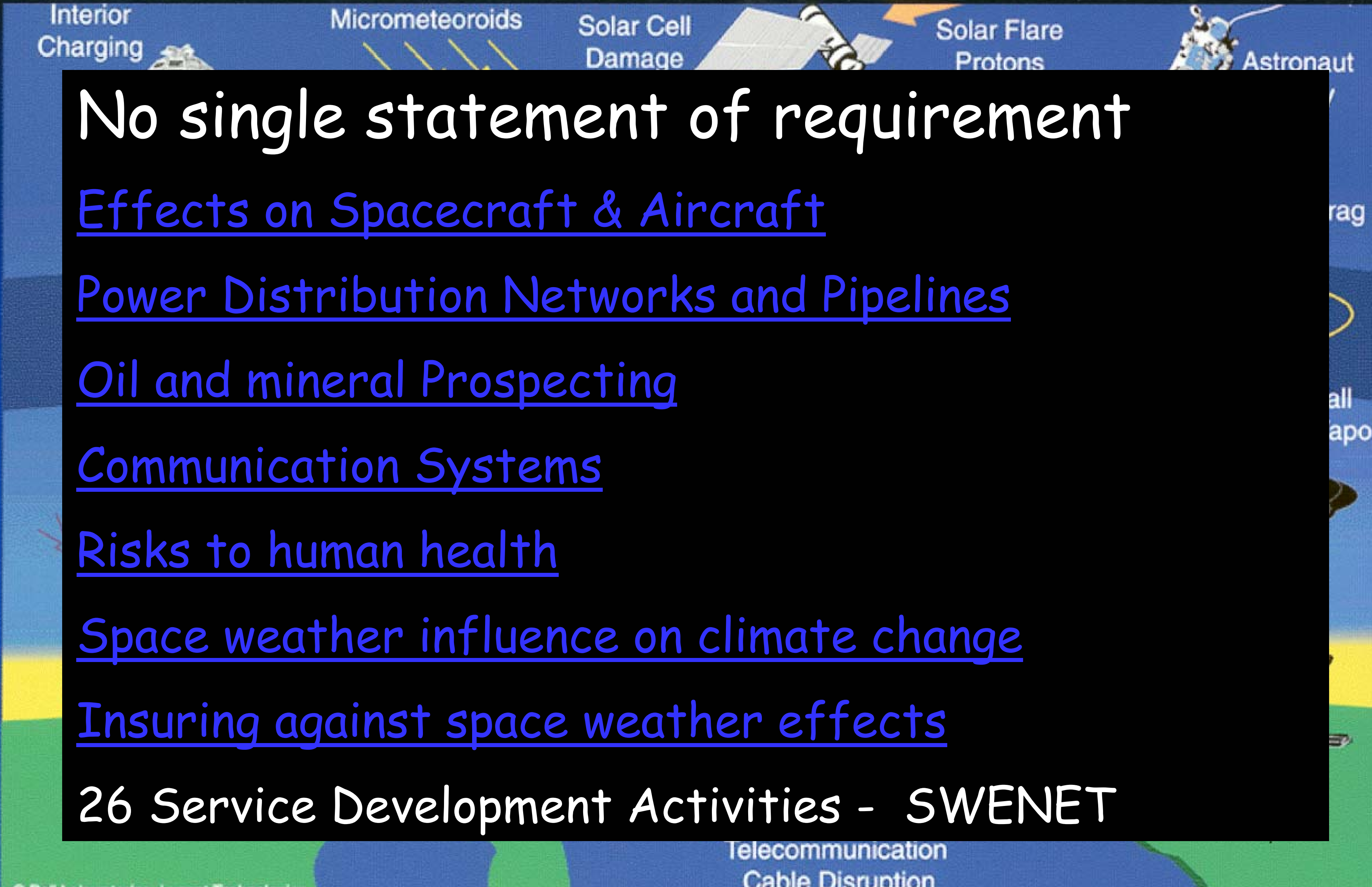
Timescales of important phenomena



Examples of time-sorted phenomena with linkage between traditional STP science:

Minutes-Hours	Days-Weeks	Months-Years	Decades-Centuries
Solar Flares	Solar Rotation	Solar Cycle	Solar Irradiance Changes
CMEs	Emerging Flux Features	Solar Dynamo	Earth Surface Temperature
Geomagnetic Storms	Trapped Particles	Solar Wind Variance	Ozone Changes
Substorms	Magnetic Clouds	Cosmic Rays	Galactic Cosmic Rays
Ionospheric Currents and Structure	Geomagnetic Storms	Middle Atmosphere Composition, Dynamics, Temperature	Maunder Minimum
Gravity Waves	Radiation Belt Dynamics	SAO & QBO	Climate Change
Turbulence			
Reconnection			
Radiation Belt Enhancement			

Space Weather Effects



No single statement of requirement

[Effects on Spacecraft & Aircraft]

[Power Distribution Networks and Pipelines]

[Oil and mineral Prospecting]

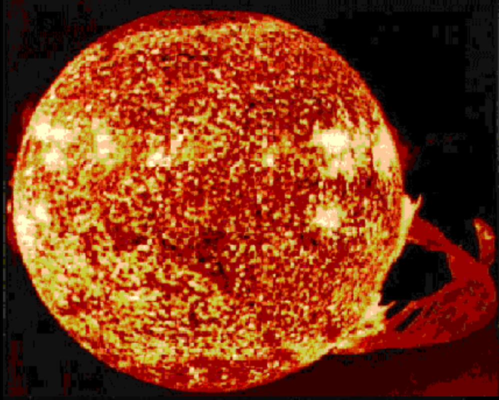
[Communication Systems]

[Risks to human health]

[Space weather influence on climate change]

[Insuring against space weather effects]

26 Service Development Activities - SWENET



User requirement

>95% reliability

Not easy to determine

commercial in confidence

Timescales

Weather and Climate

Today, 5 years, 15 years

Why can't accurate predictions be made?

What do we need to do?

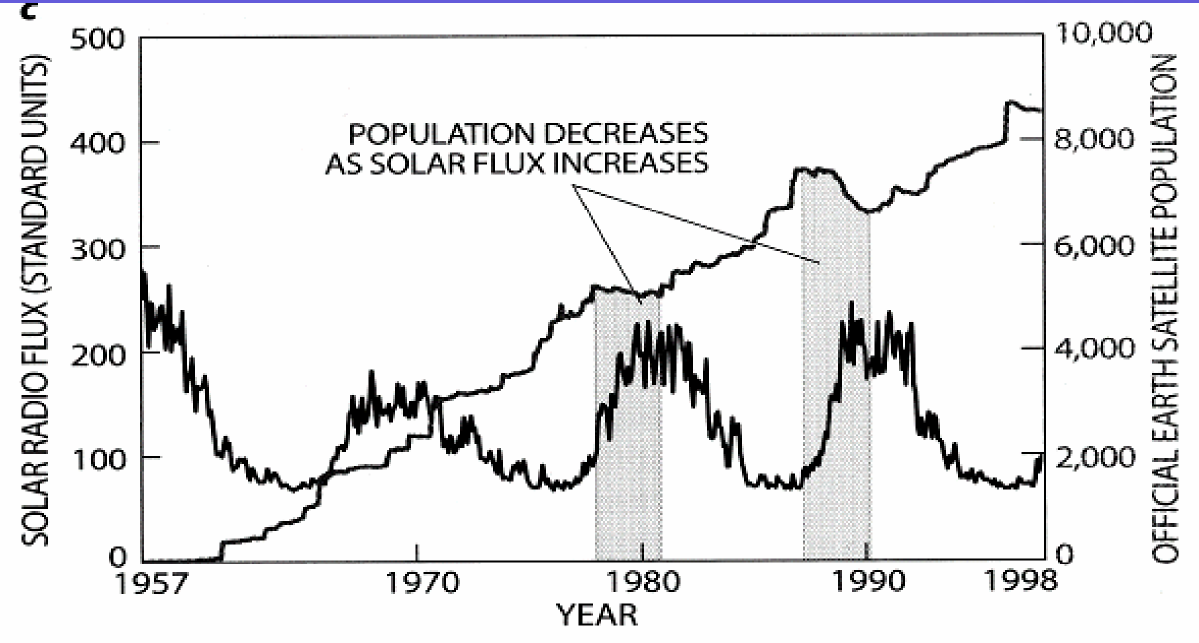
For prediction

Underpinning scientific research

Data provision

Drag

- Long term solar output
- Extreme events
  - 10^{-1} TW to 10 TW @ magnetopause; electrojet 10^{6} amps in minutes
  - Prediction/timing
  - Joule and particle heating
    - Electric field distribution
    - Conductivity



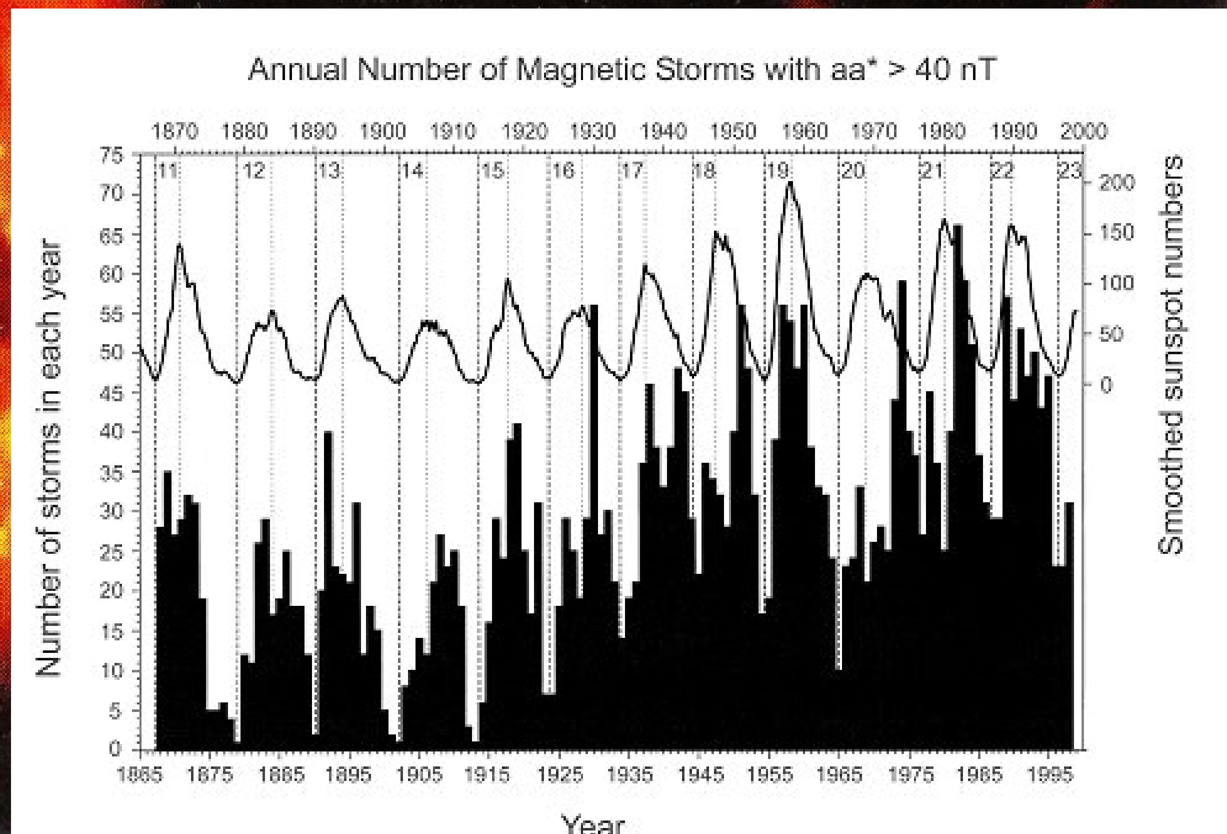
Energy inputs - climatology

Solar output as a function of wavelength and time

paleo proxies to extend the time series foE, Be10 etc

Magnetic flux

Climatology ☺



Energy inputs – weather

What do we not know?

Which are “extreme” events as they lift off the Sun?

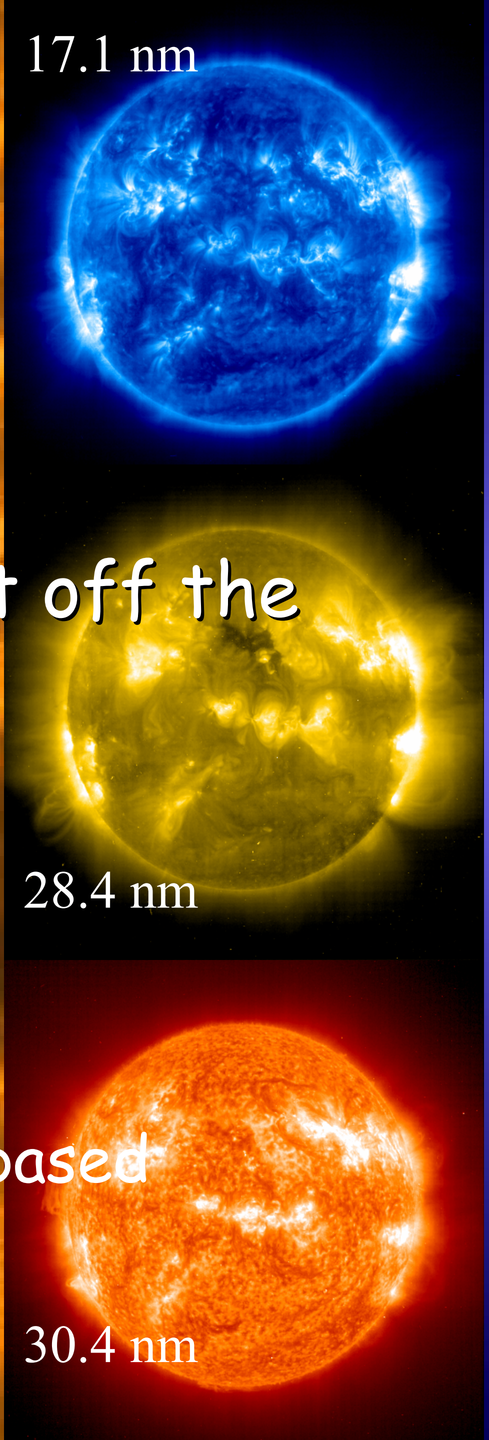
Research required – high priority

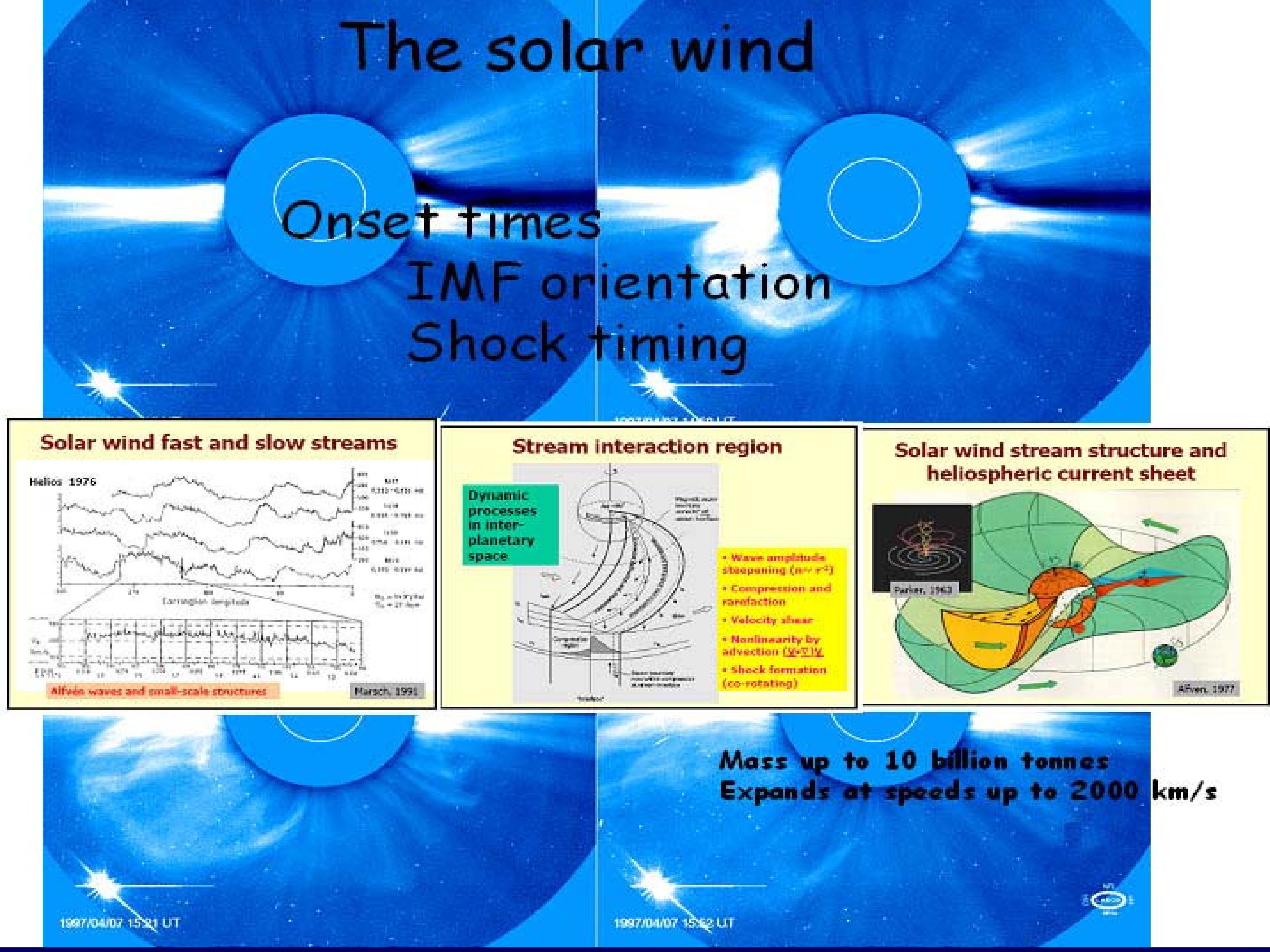
Phenomenology → Integration

The way forward

STEREO, Solar-B, Solar Orbiter and ground-based observations and theory

Timescale – 5+ years




The solar wind
Onset times
IMF orientation
Shock timing
Solar wind fast and slow streams
Helios 1976
Carrington longitude
Alfvén waves and small-scale structures
Marsch, 1991
Stream interaction region
Dynamic processes in inter-planetary space
• Compression and rarefaction
• Velocity shear
• Shock formation (co-rotating)
Solar wind stream structure and heliospheric current sheet
Parker, 1963
Alfvén, 1977
Mass up to 10 billion tonnes
Expands at speeds up to 2000 km/s

Energy deposition - substorms

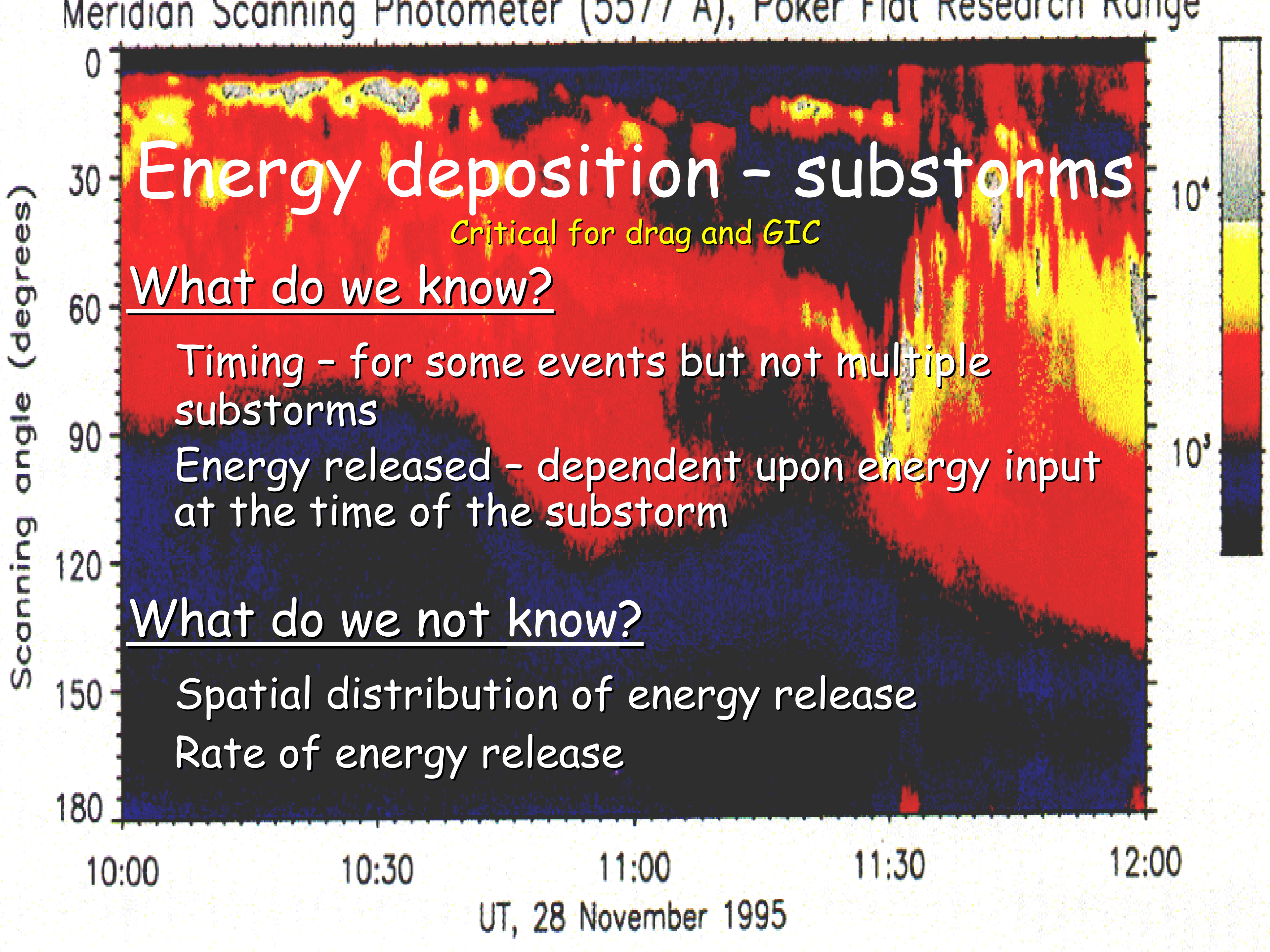
Critical for drag and GIC

What do we know?

- Timing - for some events but not multiple substorms
- Energy released - dependent upon energy input at the time of the substorm

What do we not know?

- Spatial distribution of energy release
- Rate of energy release



Substorms

What do we not know?

Spatial and temporal distribution of energy release

Research required – high priority

Location - spatial distribution of pressure in the tail

Latitude distribution - ???????

Longitude distribution - ???????

Rate of energy release - ???????

The way forward – Cluster and ground-based observations and theory

Timescale – 5 years

Timescale of operational space weather forecasting

<u>Today</u>

- empirical + assimilation
- neural networks
- prediction filters

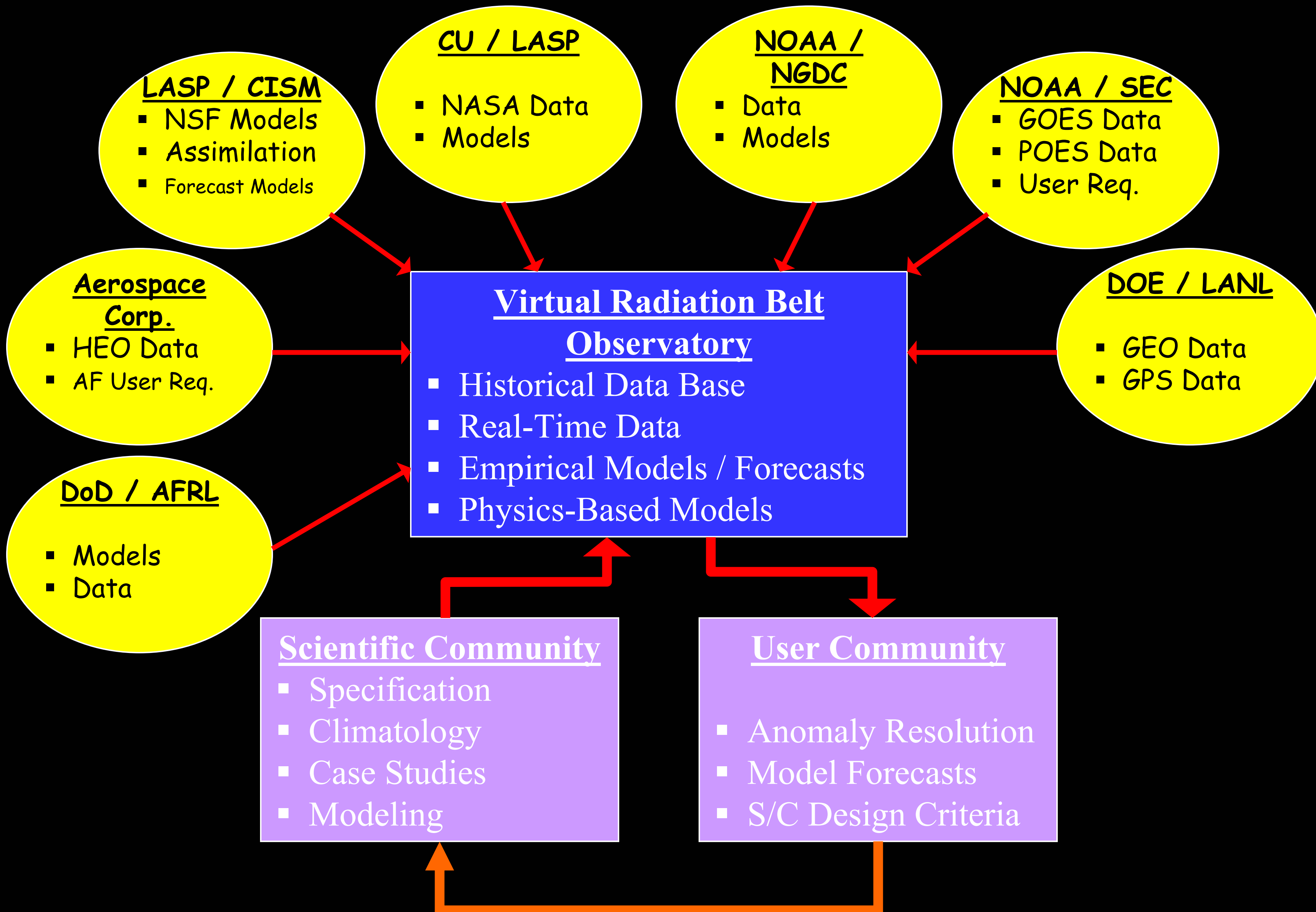
<u>5 years</u>

- empirical + more physics

<u>10+ years</u>

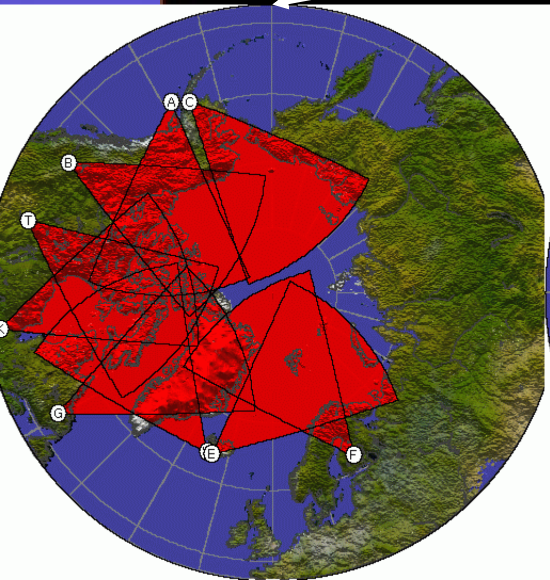
- Physics + empirical

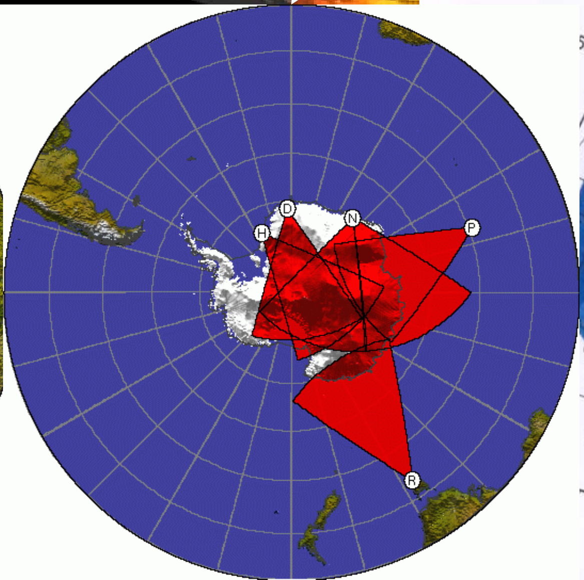
A Virtual Radiation Belt Observatory Concept

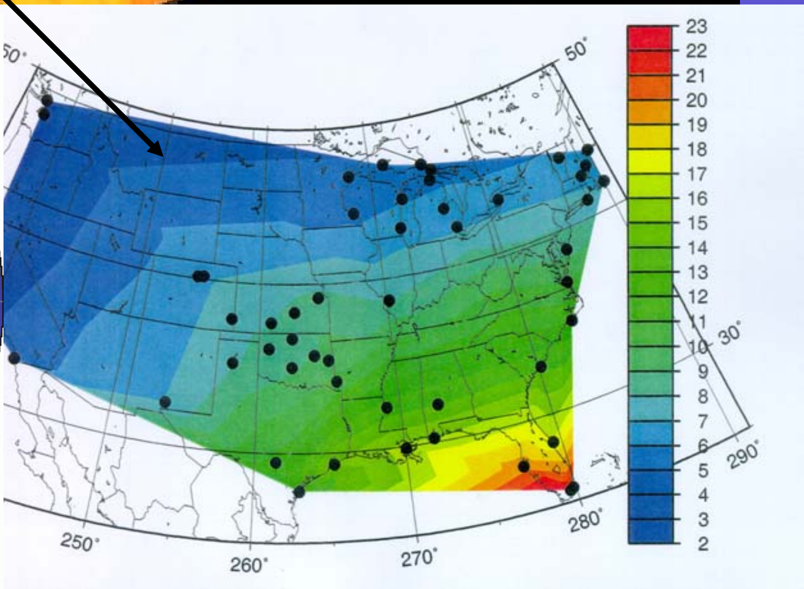


High latitude irregularity operational model

IMF
Oval Location
Conductivity from UV images + EUV model
Model neutral wind
SuperDARN electric field + model
TEC + Scintillation Maps







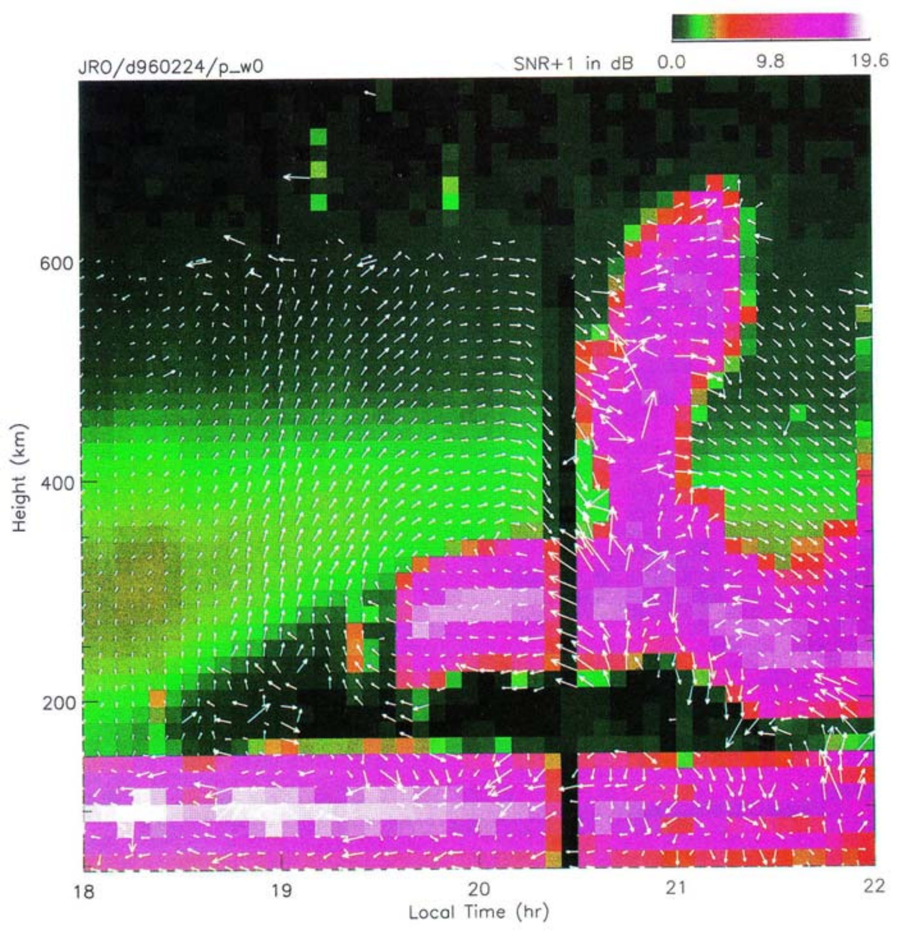
Equatorial latitude irregularity operational model

Spatial measurements of electric field
Spatial measurements of neutral wind
TEC + Scintillation Maps

Distribution of observations
Sensitivity of observations

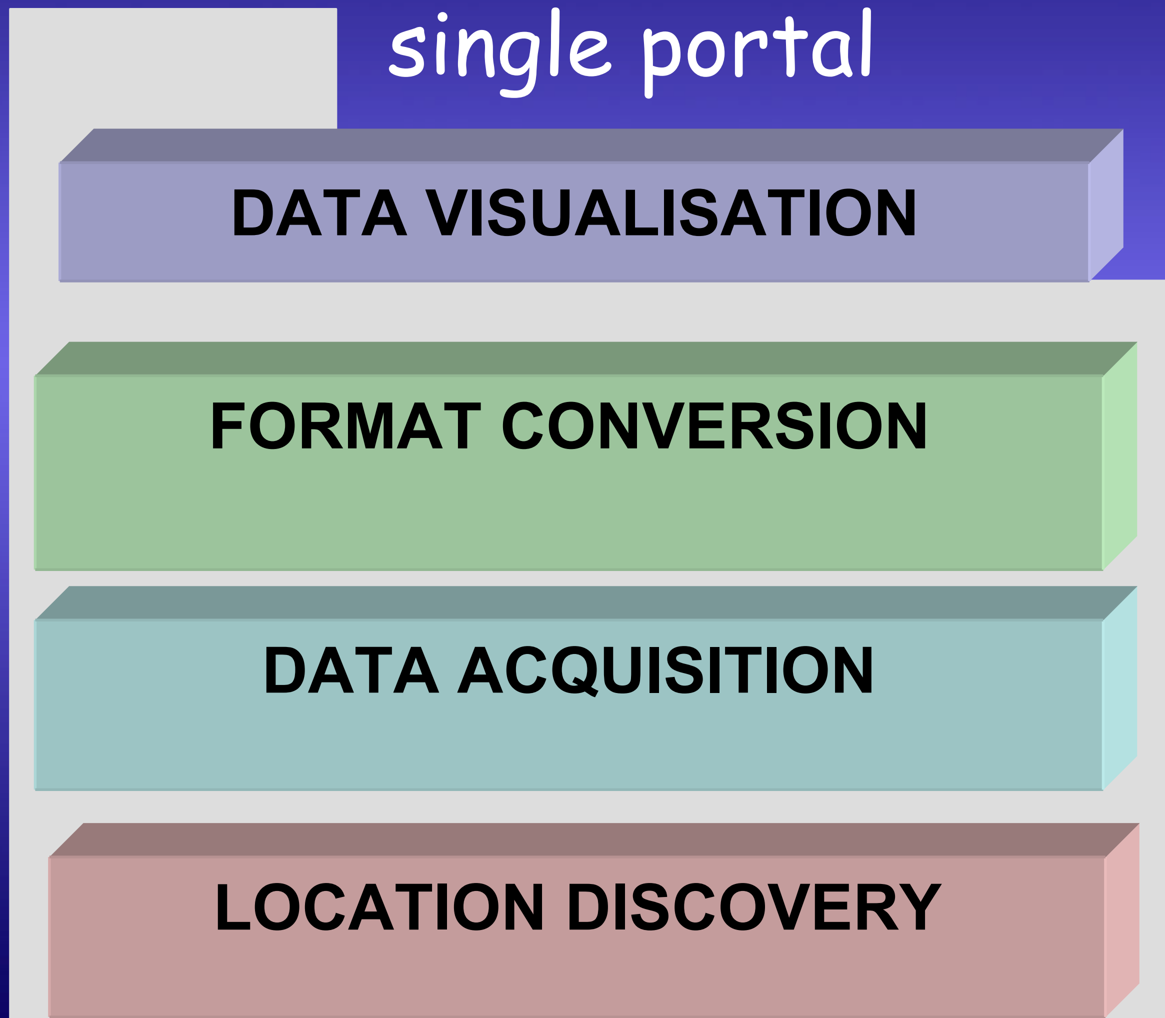
Climatology ☺

Weather X

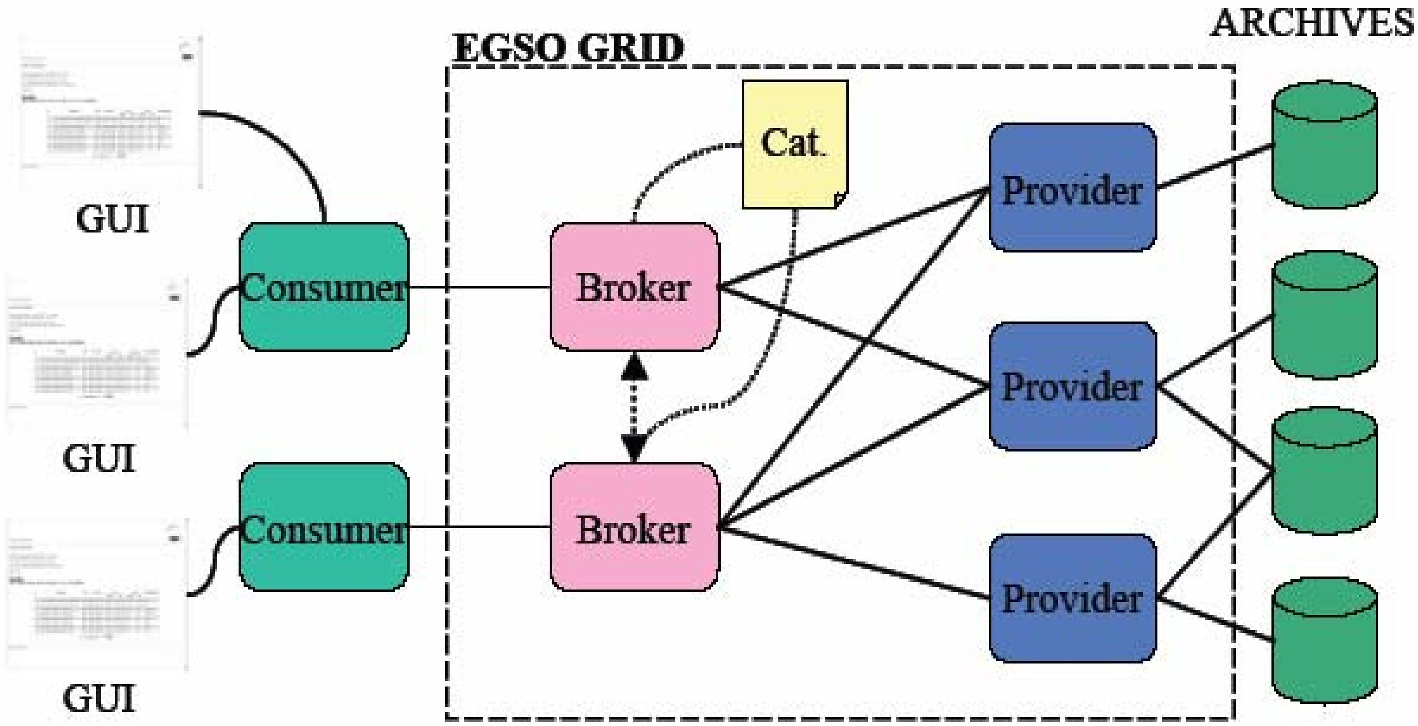


Virtual observatory components

Distributed data bases accessed through a single portal



Simplified Architecture



Architecture defined in terms of roles

Consumer, Broker and Provider

After R. Linsolas, IAS

Sun-weather/climate

Power: $4\ 10^{26}$ W $2\ 10^{17}$ W

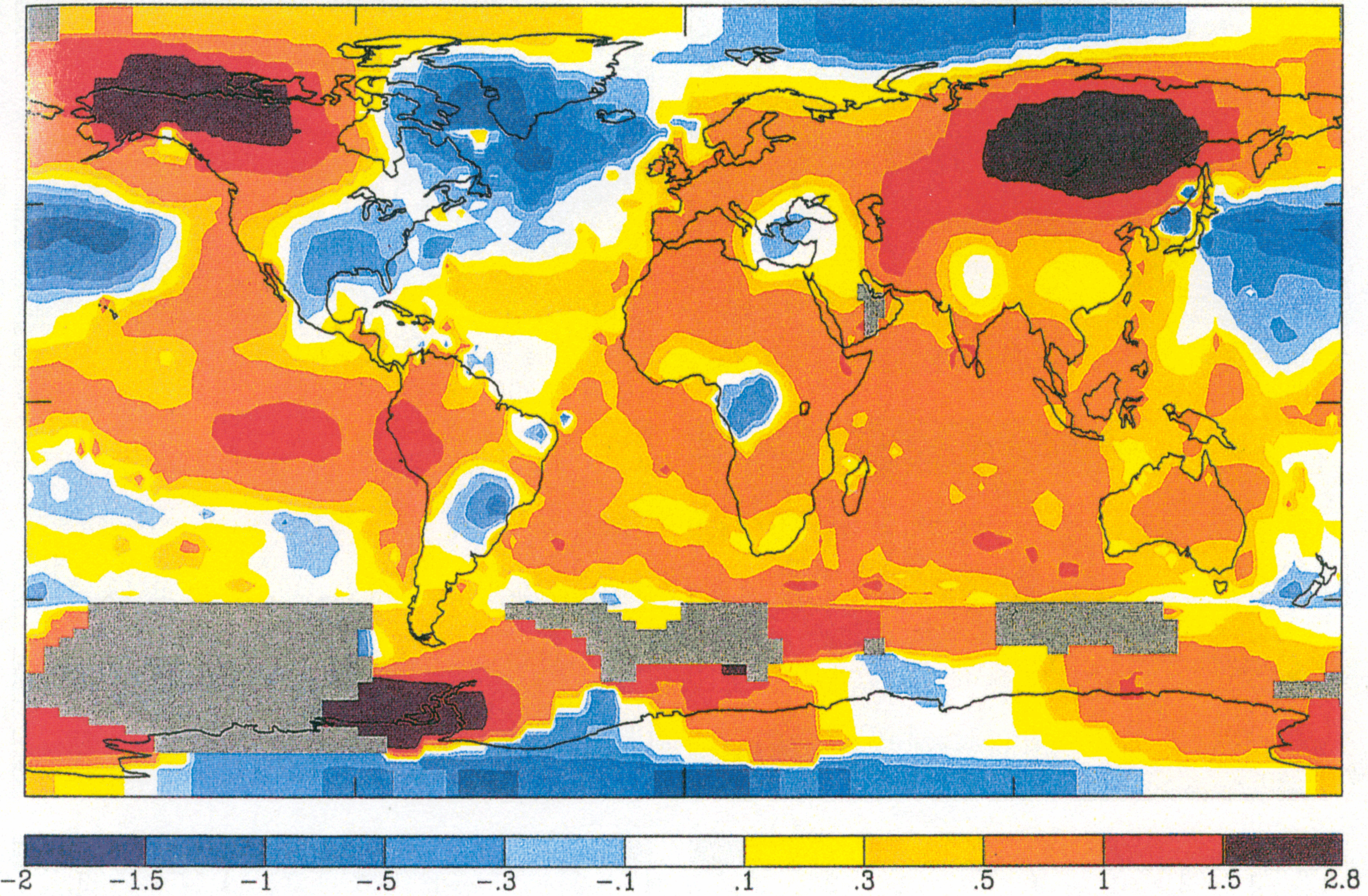
Issue: Reduce the uncertainties in predictions

Rationale: To scope mitigation and adaption strategies more accurately
Links to national and international policy

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Change of Temperature Index Based on Local Linear Trends

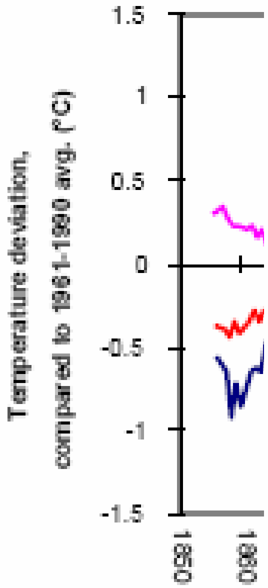
(a) 1950 to 1998 Annual Mean .43

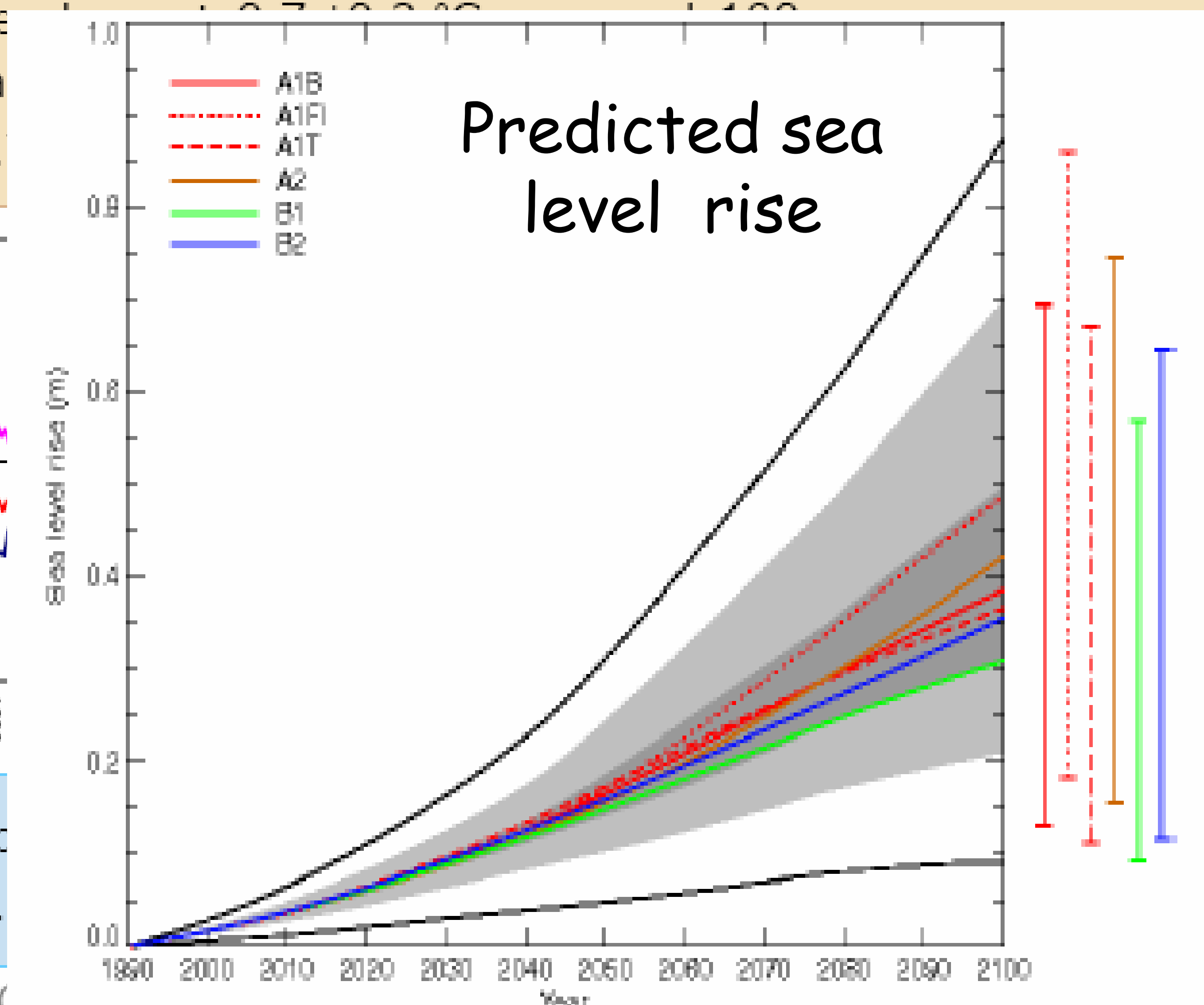


Air Temperature

- Global tempe
- Europe: mea
- Summer +0.

past trends





and

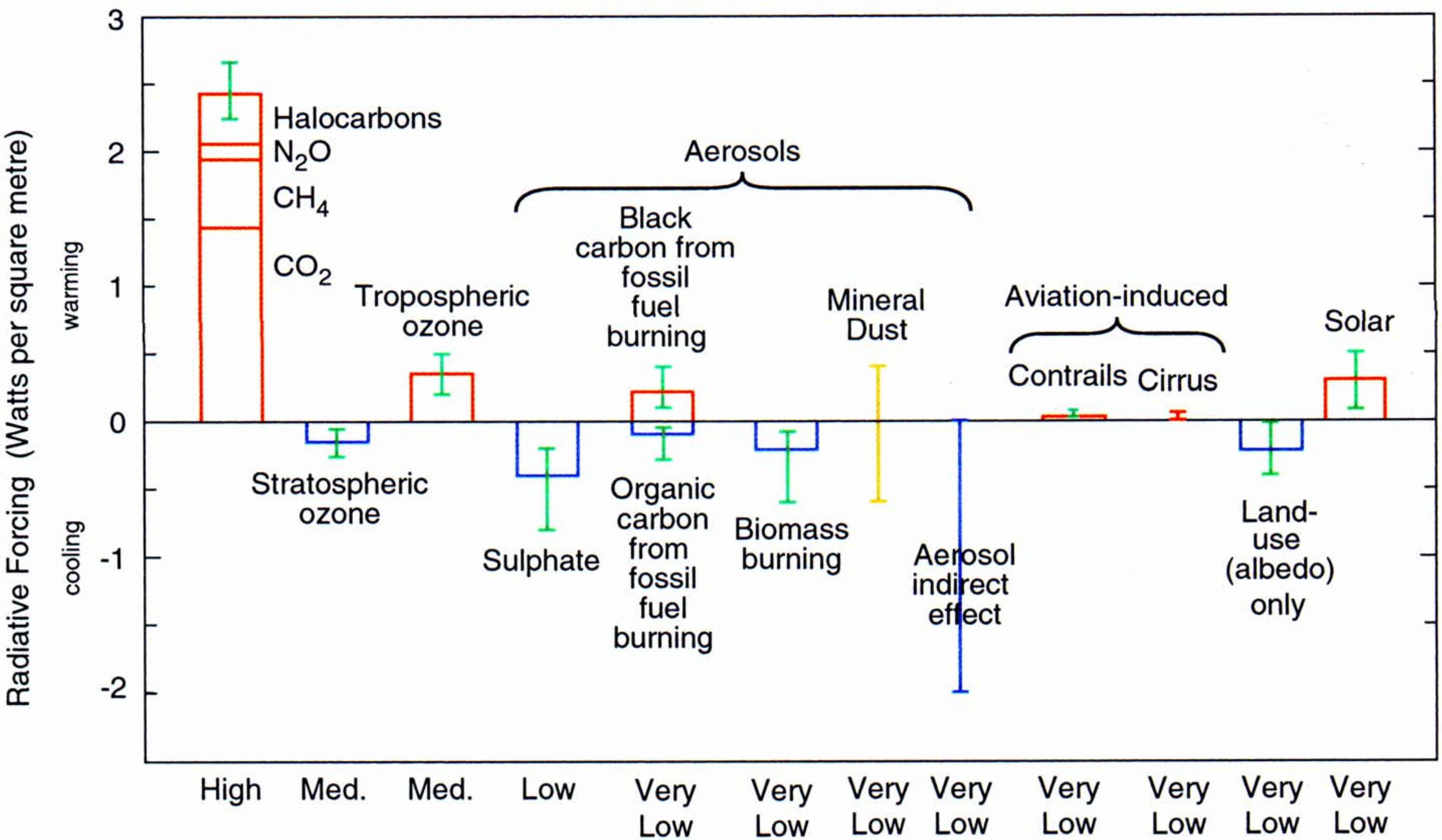
ations,

- Global projec
- Europe: + 2.

future projection

Data-sources: IPCC, ...

The global mean radiative forcing of the climate system for the year 2000, relative to 1750



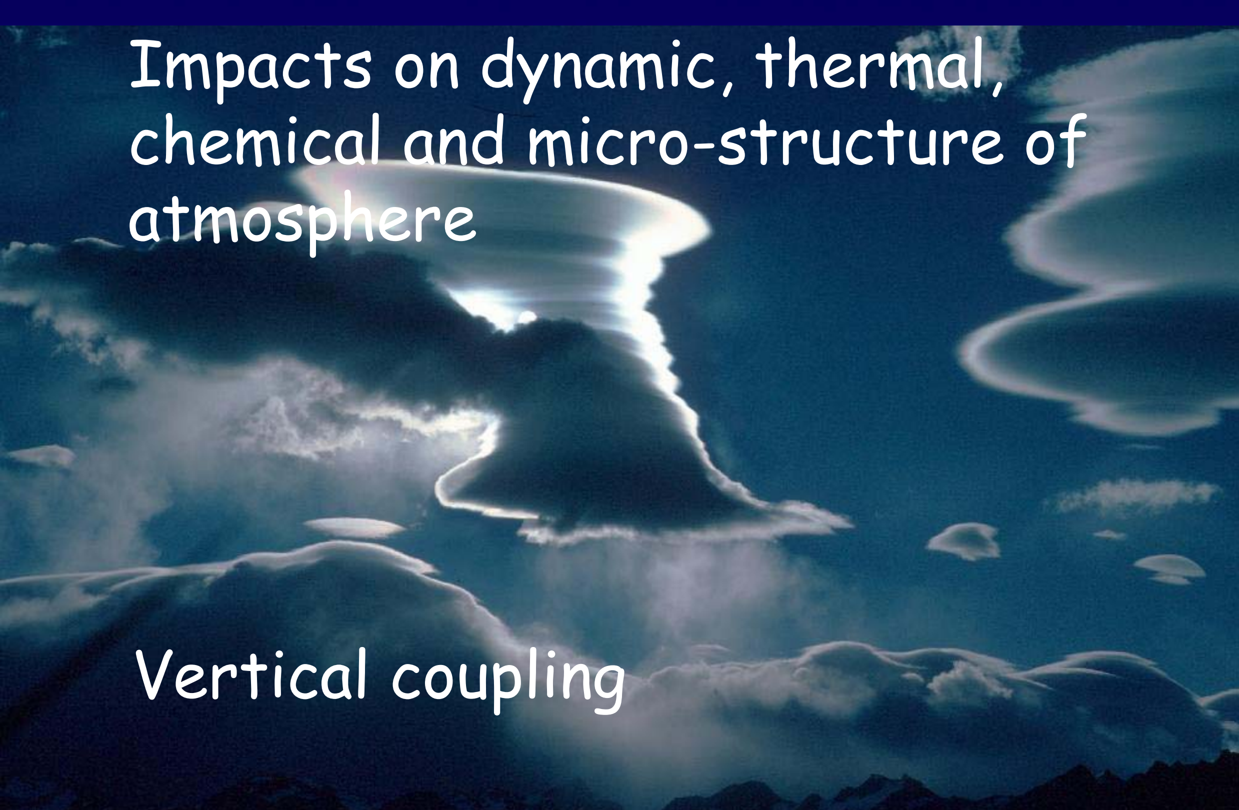
Influence of the Sun on the Earth's climate

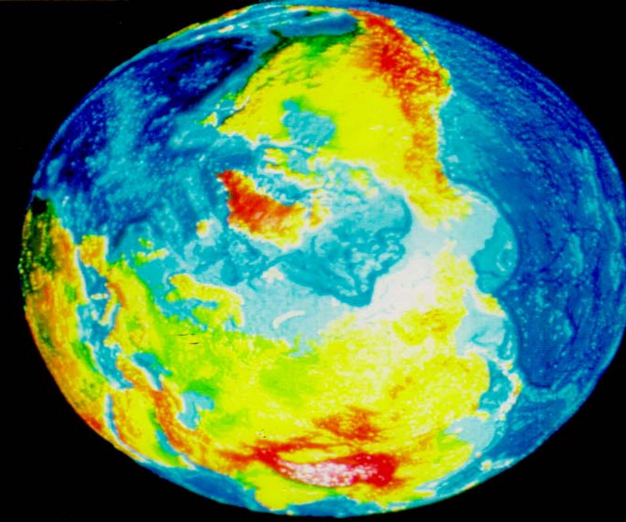
- Solar irradiance
  - Total solar + spectral
- Long term changes in solar activity
  - Paleo data constructions
- Planetary wave reflection
- Aerosols/clouds
  - electric fields
  - cosmic rays

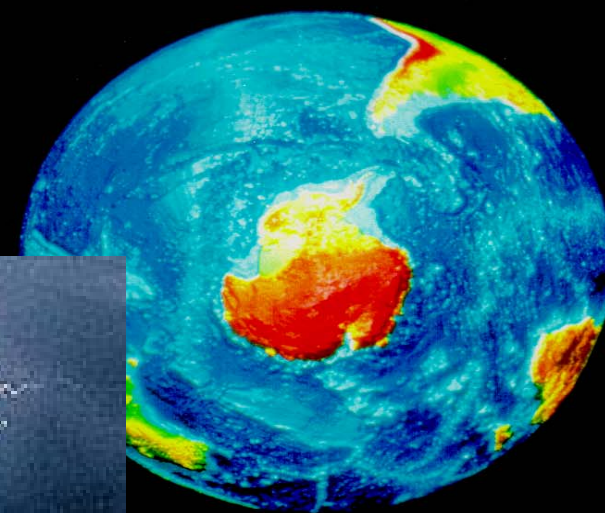
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

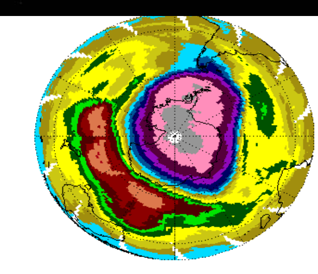
Impacts on dynamic, thermal, chemical and micro-structure of atmosphere

Vertical coupling









Influence of the Sun on the Earth's climate

Science Objectives

Review previous statistics to establish a robust baseline of facts

Quantify the magnitude of the various mechanisms in the troposphere to determine which ones are important

Transferring science results into policy

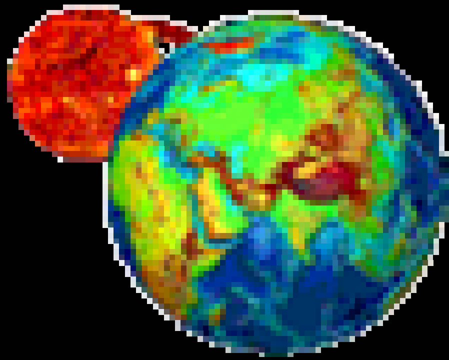
Influence of the Sun on the Earth's climate National and international programmes

ISSI Workshop on Solar Variability and Atmospheric Composition, Temperature and Circulation Variations on Terrestrial Planets Bern, Switzerland, June 6 to 10, 2005

European Solar Terrestrial and Atmospheric Research (E STAR)

Climate And Weather of the Sun-Earth System (CAWSES)

International Living With a Star (ILWS)



The future

Framework 7 2007-2013

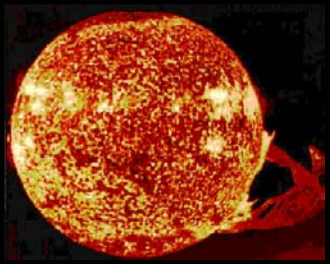
Specific programme opportunity

Intergovernmental Panel on Climate Change (IPCC) -2007

International Year Initiatives

Several global "I*Y" initiatives are under development

I*Y Years	Name	Main Sponsor	Website
eGY 2007-2008	Electronic Geophysical Year	IUGG	http://www.egy.org
IPY 2007-2009	International Polar Year	ICSU WMO	http://dels.nas.edu/prb/ipy/
IHY 2007-2008	International Heliophysical Year	NASA	http://ihy.gsfc.nasa.gov
CAWSES 2004-2008	Climate and Weather in the Sun-Earth System	SCOSTEP	http://www.ngdc.noaa.gov/stp/SCOSTEP/scostep.html



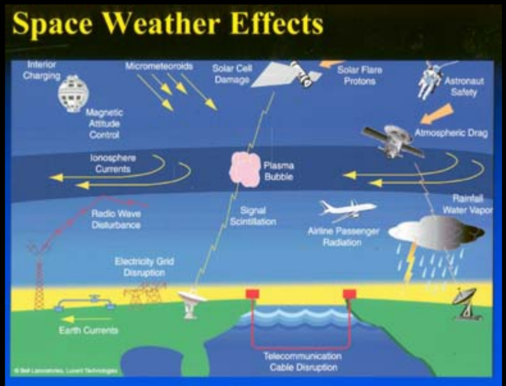
The way forward

Comparison with the meteorological community

National and international cooperation over data collection – funded by Governments

Specific forecasts and products produced by business enterprise

Further research funded by Governments



European Sun/Space-Weather/Climate Data Network

Concept for multiple virtual observatories

Objective

To bring existing data together to address sets of scientific and operational goals

Need for coordination and investment

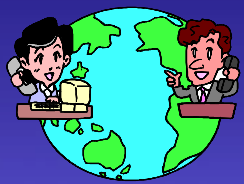
(European Digital upper Atmospheric Server, DIAS)

World data centre role in 21st Century + Regional Warning Centres (ISES)

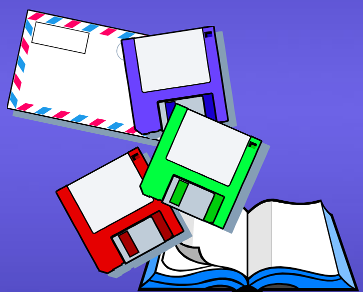
Common approach/feel/analysis tools/standards with a real time element

To get scientific data from various, mostly distributed sources, a scientist may have to:

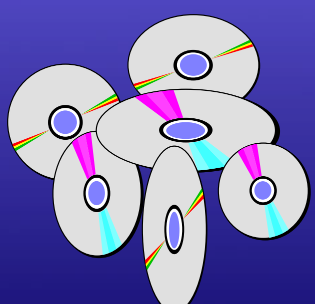
1. Search through a number of data centres, various institutions, observatories, contact colleagues…



2. Get data via snail-mail, air-mail, e-mail, Web…

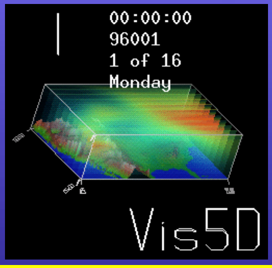


3. Then ingest retrieved data into a local database…



4. Process collected data using mostly proprietary codes, run models… and…

5. Finally, do some sceince



<u>Increasing requirements</u>

Interdisciplinary and multi-disciplinary science

Higher resolution – space and time

Assimilation into models

Key Conclusions

<u>Space Weather/Climate</u>

User needs

- generic data collection – government
- individual forecasts for specialist sector

Next objectives

- empirical approach with limited physics
- extreme event prediction

<u>Sun Weather/Climate</u>

- robust review of existing literature
- focus on quantification

Maximise forthcoming opportunities

Integrate Space-Weather and Sun-Weather

- economic <u>AND</u> sustainability benefits