

“Thoughts about complementary instrumentation and possible EU space weather initiatives”

Ian McCrea

STFC Rutherford Appleton Laboratory

Complementary Instruments in the Science Case

- In the final version of the EISCAT_3D science case, there was a six-page appendix (Appendix 3) dedicated to complementary instruments and their role in realising the science case.
- The sections of this appendix were:
 - Optical instruments
 - Radars
 - Rocket ranges
 - Other ground-based instruments
 - Site configuration of instruments

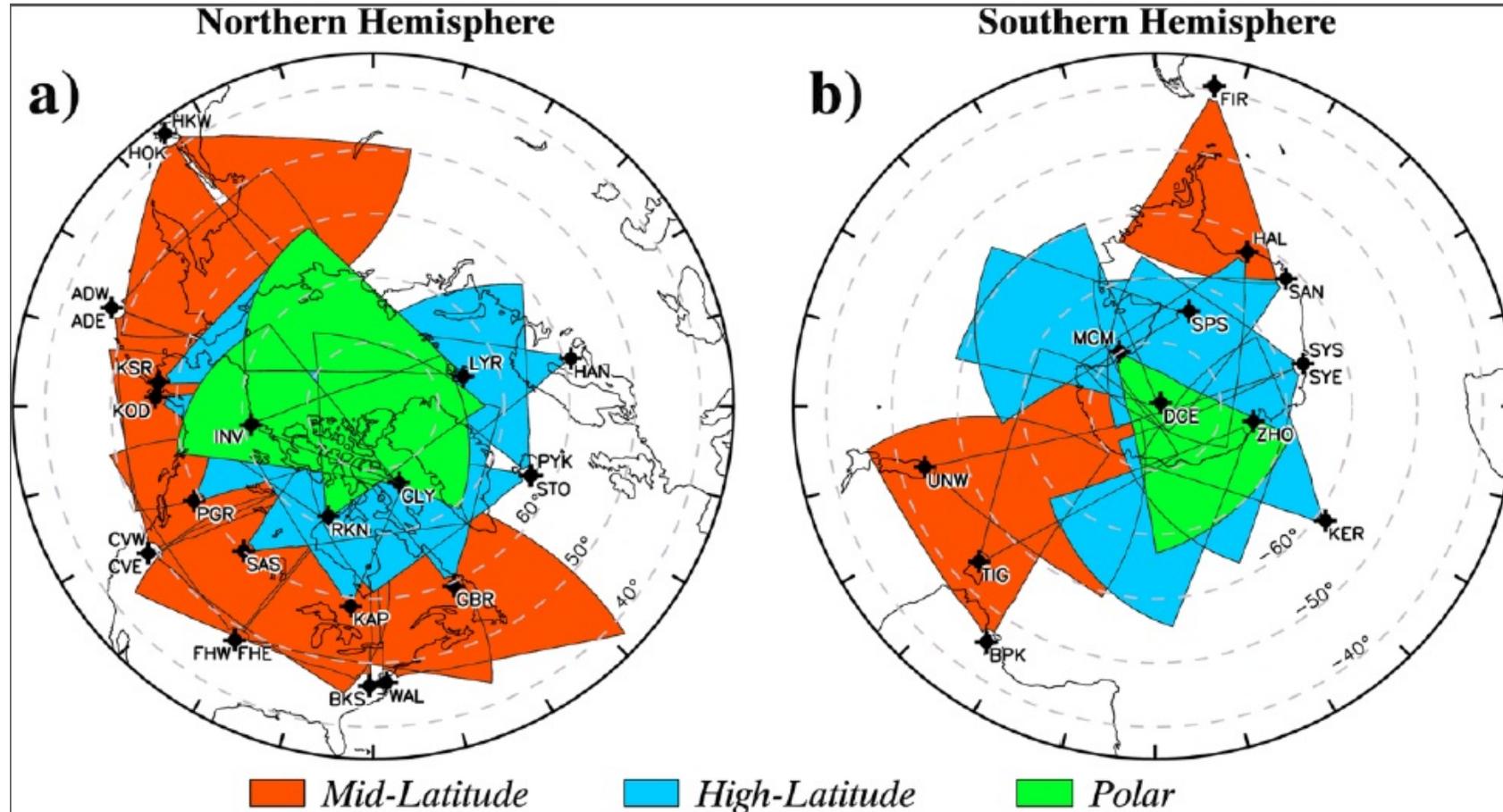
Optical Instruments

- Classes of instrument mentioned
 - All-sky imagers (separately or in a network)
 - Wide-field and narrow field
 - Multi-spectral imagers
 - Meridian scanning photometers
 - Spectrometers
 - FPIs/SCANDI
 - Lidar systems
- Division between wide-field survey instruments and small-scale specialised applications:
 - High-resolution, multi-spectral imaging
 - Auroral tomography
 - (Maybe think about a tracking optical sensor?)

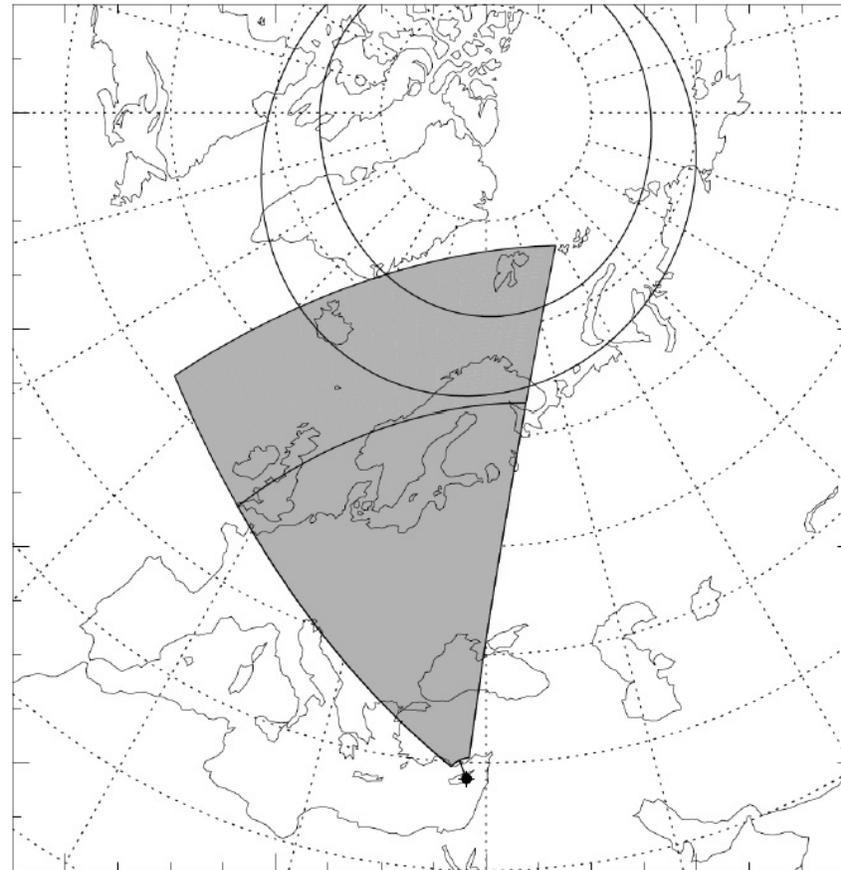
Radars

- Classes of instruments mentioned
 - MST Radars
 - Some already exist in northern Scandinavia
 - Meteor Radars
 - As above, some systems already exist
 - SuperDARN
 - Northern Scandinavia covered by existing systems
 - Still not optimal for EISCAT_3D?
 - Ionosondes
 - A few exist, but EISCAT may need its own (e.g. for heating)
 - Non-ISR uses of EISCAT_3D
 - Meteor Radars
 - Satellites and space debris
 - Stratospheric winds

SuperDARN Network Coverage



Proposed new Cyprus Radar



Rocket Ranges and Other Ground-Based

- Rocket ranges
 - ESRANGE
 - Relevant already in Phase 1
 - Andoya
 - Becomes more relevant if we get to Phase 3
- Other ground-based instruments
 - HF Heating
 - Strongly tied to EISCAT and its science
 - KAIRA
 - Works as a bistatic radar
 - A number of ionospheric applications (cf LOFAR)
 - Riometers
 - Magnetometers
 - GPS receivers
 - These are distributed survey instruments

Site Configuration of Instruments

- On site instruments
 - These are strongly related to EISCAT community science
 - High resolution imagers
 - Other distributed imagers
 - Lidars
 - Ionosonde (for a collocated heater?)
 - Middle atmosphere radars (collocated, or joint volume?)
- Distributed supporting instruments
 - Large-scale optics
 - SuperDARN
 - Riometers
 - Magnetometers
 - GPS
- Much of the supporting data we want would come from instruments not belonging to us
- These might primarily exist for the additional purpose of making underpinning observations for European space weather monitoring.
- But, how would such instruments be funded??

ESA SSA Programme

- ESA is operating two Space Weather “Expert Centres” using ground-based data
- The ionospheric ESC (DLR, Germany), monitoring and forecasting for:
 - TEC
 - Scintillation index
 - Critical frequency predictions
 - Solar flares
 - Thermospheric densities??
- The geomagnetic ESC (was Tromso, now needs new tenders)
 - Geomagnetic indices
 - B-field monitoring and forecast
 - Auroral predictions
 - Electrojet strength
 - Storm alerts
 - dB/dt

Ground-based instruments for European Space Weather

- We might argue to get things like.....
 - Ionospheric profiling
 - TEC
 - Scintillation monitoring
 - Wide-scale auroral monitoring
 - Large-scale electric fields
- ...over northern Scandinavia supported as part of European space weather initiatives
- These address parameters in the ESA remit
 - But ESA is constrained and does not really support ground-based instruments
 - But the landscape seems to be changing somewhat....

What can EISCAT_3D do itself?

- We could also contribute to operational space weather/SSA
 - TEC
 - Ionospheric profiles
 - Mapping of gradients
 - E-fields
 - Conductivities/currents
 - Satellites and space debris
- But how to do this?
 - EISCAT's own services or high-level parameters
 - Raw data to ESCs for onward processing

Two possible roles....

EISCAT needs to think about its own role in space weather/SST:

- Is it a service provider in its own right?
 - This means making some services, based on its data
- Or is it a data source, providing data to others
 - Are such data free, or are they charged as a commercial service?
 - Nobody can make much money from the ESA SSA programme

The time to consider this is NOW....

- We have the ability to do this
 - EISCAT_3D could spend some of its time making routine space weather observations
 - LOFAR is already studying how to do the same thing
 - This is being done with EU money
 - LOFAR for Space Weather, EU SST
 - Not a clear connection to ESA activities?
- ESA is making study money available for EISCAT_3D to make this case
 - However it has always been difficult to fund, for ground-based equipment

Complementary instruments and space weather

- In our instrument roadmap, we need to separate:
 - What is truly supporting (supplementary) infrastructure for EISCAT_3D
 - Located on (or very close to) the radar site
 - Specific gearing to our science programme
 - Relies on national funding, predicated on EISCAT case?
 - What is more generic instrumentation for a European space weather programme
 - These are the complementary instruments, also doing other things
 - Networked instruments, covering northern Scandinavia
 - Data used in provision of general products and services
 - Can be funded as part of bigger applications programmes

Future of Space Weather in Europe

- ESA has been providing operational space weather
 - As a prototype service under SSA
 - Supports small contracts to provide data to the ESCs
 - But this funding is for service providers
 - ESA has not been funding ground-based systems
 - So we need another space weather stakeholder to look after ground-based
- ESA might not continue running SSA as an operational service
 - Other players are emerging: EUMETSAT? PECASUS (IKO?)
 - EU might be one of the most interesting candidates....

Possible new EU Programme

- EU has been considering for some time to establish a Space Situational Awareness programme
- Would have the same three headings as ESA
 - Space Weather
 - Space Surveillance and Tracking
 - Near Earth Objects (discussed but not certain)
- Commission held a “Users Meeting” to discuss, at end February
 - About 50 attendees, not many users
 - A lot of interest from existing data and service providers
 - ESA and EUMETSAT were there
 - Might signal a greater convergence of international providers

What is happening now?

- High-level discussions on EU multi-annual financial framework
- An EU SSA programme (from 2021) is definitely under discussion
 - Would include space weather
 - Discussions of funding in tens of millions (Euros)
 - Commission seems to be consulting and taking advice
 - They are aware of what ESA cannot do
- This could be a sign of EU working with ESA, looking toward a real operational programme

What is happening now?

- ESA is talking about a “Safety in Space” programme as one of its four new pillars
 - Applications
 - Science & Exploration
 - Enabling and Support
 - Safety and Security (in space and from space)
- The Safety in Space programme would have three pillars
 - Space Weather
 - Planetary Defence (NEOs?)
 - Space Debris and Cleanspace
- Each pillar might have a keynote space mission
 - Lagrange, HERA, e-DeOrbit
 - But this is very much a space-based focus

Landscape for European Space Weather...

- More like the situation in the US?
 - NASA supports space weather for its own programmes
 - Has a lot of capability in CCMC, extending into community
 - NOAA has the engagement with the non-NASA user community
- Possible that ESA will move toward the NASA-like role?
 - Focus on space-based and relevance to its own programmes
- Some other body might engage with the other user communities
 - The operational successor to the ESA SSA programme
 - Perhaps the EU is shaping up to do this, or support it
 - We should stress the importance of non-space-based systems

Space Surveillance and Tracking

- This will also be very significant!
 - Will have EU and ESA resources
 - Increasing national interests in this, e.g. national launch facilities
- Five European Space Agencies (DE, FR, ES, IT, UK) already collaborating
 - Establishing a European sensor network
 - Joint tasking, data sharing, joint catalogues
 - International collaboration and support
- ESA and EU are both active here
 - Lots of interest in surveillance radars at northern latitudes
 - Nicolas Bobrinsky very supportive of the EISCAT studies
 - But there are aspects here which we would have to consider
 - Could be potential for research activities, however

Operational Focus

- As well as our science focus, we should acknowledge this new operational focus
- It plays well to an agenda of practical impact, which governments understand
- We have the ability to support it ourselves
 - though we have to think about how
 - not at the expense of our science programme
- We could also leverage very useful support from the ground-based instrument networks that it might support